Groundwater Monitoring Program (GWMP)

Clover Power Station – Sludge Sedimentation Basins

Clover, Virginia

March 2017, revised April and October 2017

Prepared For
Virginia Electric and Power Company

R. Kent Nilsson, PE
Senior Engineer

Gregory E. Tieman, PG
Senior Hydrogeologist

30 PATEWOOD DRIVE, SUITE 300, GREENVILLE, SC 29615, ● 864.281.0030 PHONE ● 864.281.0288 FAX ● WWW.TRCSOLUTIONS.COM

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Section 1
Introduction

The Clover Power Station (Station), owned[1] and operated by Virginia Electric and Power Company d/b/a Dominion Virginia Power (Dominion), is located just west of the Roanoke River, approximately 20 miles north-northeast of South Boston, Virginia (see Figure 1-1). The facility operates two coal-fired generation units that produce Coal Combustion Residuals (CCR) as a byproduct of electrical generation. Currently, the facility operates two lined Sludge Sedimentation Basins (basins) that receive process wastewaters and flue gas desulfurization (FGD) sludge. The two basins occupy a total area of approximately 4 acres. The locations of the basins are illustrated on Figure 1-2.

1.1 Background

On April 17, 2015, the United States Environmental Protection Agency (USEPA) finalized national regulations that provide a comprehensive set of requirements for the management of CCR from coal-fired power plants (40 CFR Part 257, Subpart D; CCR Rule). The CCR Rule establishes technical and operating requirements for CCR landfills and surface impoundments under subtitle D of the Resource Conservation and Recovery Act (RCRA). In addition, this rule requires the installation of a groundwater monitoring system and development of a groundwater monitoring program that includes consistent sampling and analysis procedures for the detection of hazardous constituents and other monitoring parameters that potentially could be released from CCR units.

The existing active basins are also being permitted as Solid Waste Management Units (SWMUs) under the Virginia Solid Waste Management Regulations (VSWMR). 9VAC20-81-250 of the VSWMR also requires the installation of a groundwater monitoring system and development of a Groundwater Monitoring Program (GWMP) capable of determining the unit's impact on groundwater quality in the uppermost aquifer.

1.2 Purpose and Scope

The purpose of this GWMP is to describe the groundwater monitoring system and the methods and procedures for collecting, analyzing, and evaluating groundwater sampling data obtained from the uppermost aquifer underlying the basins at the Station. The GWMP requirements, which are contained in Sections 257.90 through 257.98 of the CCR Rule and 9VAC20-81-250 of the VSWMR, were developed to ensure that potentially impacted groundwater at new and

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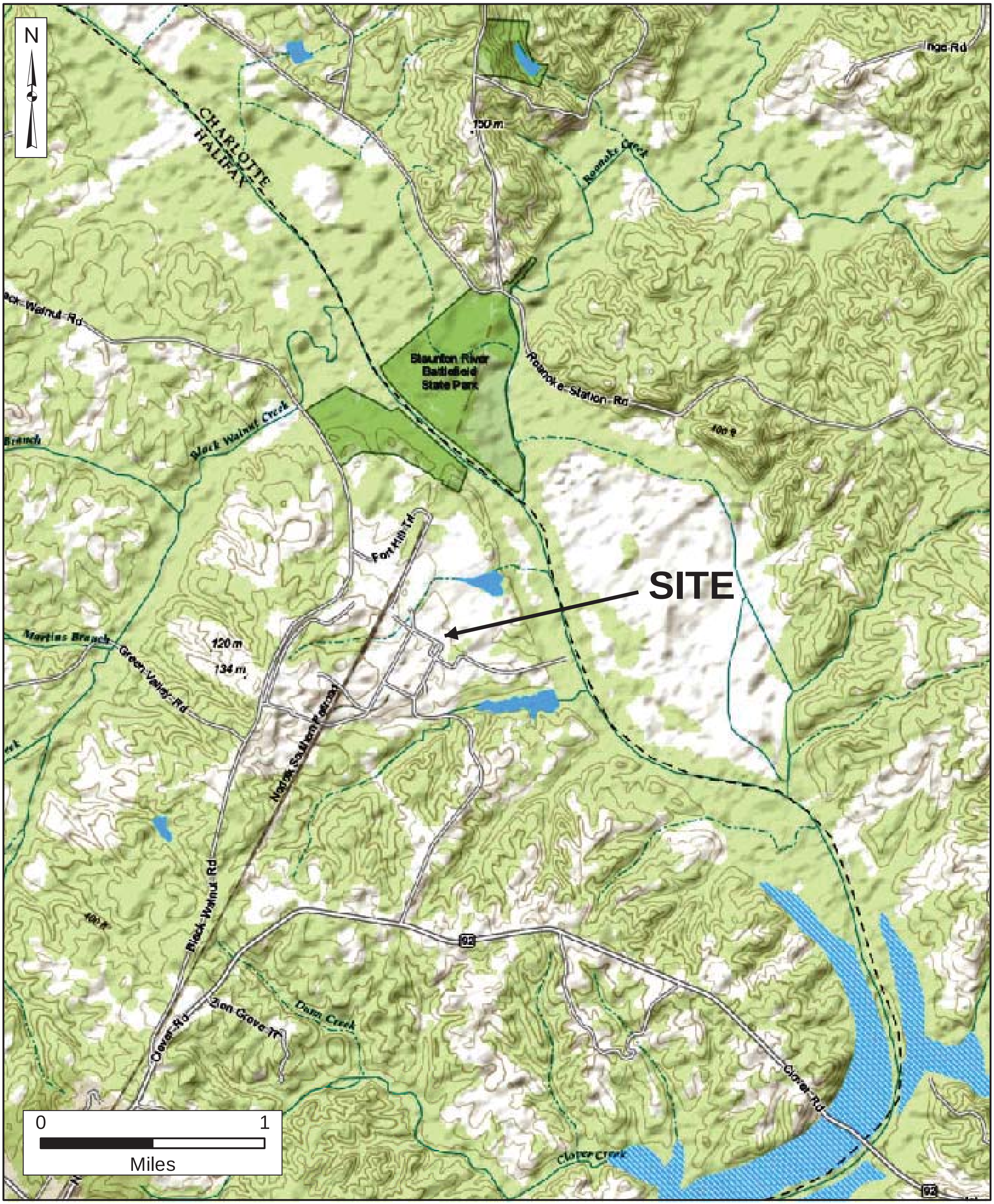
[1] Old Dominion Electric Cooperative owns a 50% undivided interest in the Station.

existing CCR units or SWMUs, respectively, will be detected and corrective measures implemented as necessary to protect human health and the environment. Both GWMPs require the development of background concentration values and the performance of two levels of monitoring. The CCR Rule GWMP consists of detection monitoring and assessment monitoring while the VSWMR GWMP consists of first determination monitoring and Phase II monitoring. While addressing the requirements of both the Federal and State programs, groundwater monitoring conducted under this GWMP combines the parameters of these two individual programs into a single list called the Modified Assessment Monitoring Program. The details of this combined monitoring are described in Section 4.1. In the event that future amendments to the VSWMR or CCR Rule conflict with any provisions of this GWMP, the VSWMR and CCR Rule requirements will supersede this GWMP, with the exception of VA Department of Environmental Quality (VDEQ)-approved variances and Alternative Source Demonstrations (ASDs), and any attached permit-specific conditions that are more stringent than the VDEQ regulations.

Section 2 describes the geologic and hydrogeological characteristics of the Station and the basins, which forms the basis for development of the CCR unit's groundwater monitoring system. Section 3 describes the locations and depths of the monitoring wells in the groundwater monitoring system at the basins. Section 4 identifies the field and laboratory analyses, detection and assessment monitoring, and groundwater protection standards (GPS) making up the GWMP. Section 5 describes the sampling and analysis procedures to be followed and includes procedures and techniques for sample collection, sample preservation and shipment, analytical procedures, chain-of-custody control, quality assurance and quality control (QA/QC), and data validation. Section 6 describes the data evaluation process. Section 7 describes reporting requirements of the two programs. Section 8 provides the references used in the development of this document.



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Patewood Plaza One, Suite 300
30 Patewood Drive
Greenville, SC 29615-3535
Phone: 864-281-0030
FAX: 864-281-0288

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FIGURE 1-1
SITE LOCATION

Drawn By: RSW	
Checked By: LMC	
Approved By: NWA	
Project No.: 232002.0.0	
Date: JULY 2015	

Path: \\ntapa-grnville\gvl-vol2\data\Projects_Vision\232002 - Dominion Clover\ArcGIS10\Fig1_Site Location.mxd
Date Saved: 7/22/2015 10:20:37 AM

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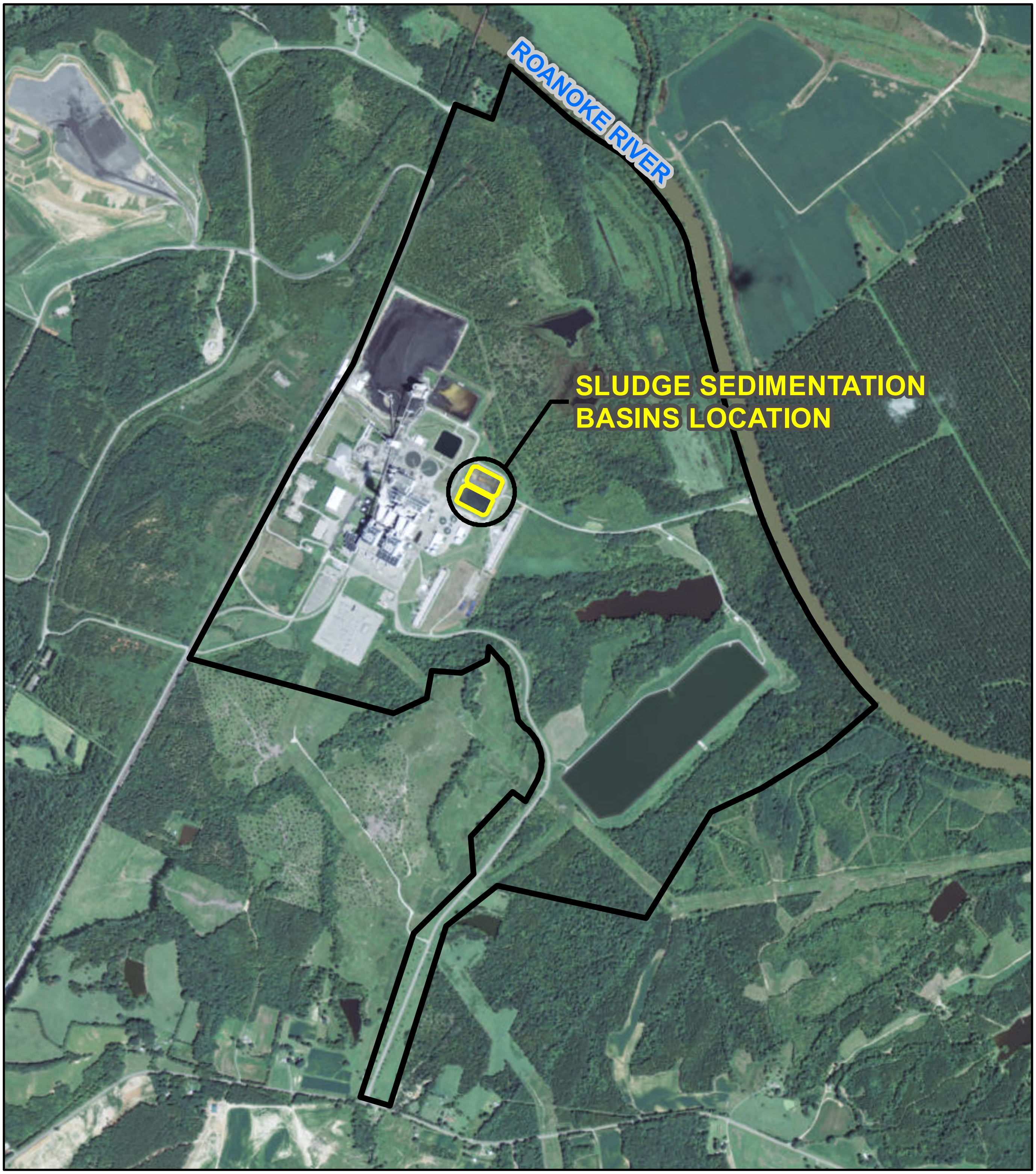
TRC - GIS



BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES

1 " = 1,500 '
1:18,000

0 1,500 3,000 Feet

Legend

APPROXIMATE PROPERTY BOUNDARY

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FIGURE 1-2
SLUDGE SEDIMENTATION BASINS LOCATION

	AMF
APPROVED BY:	LMC
PROJECT NO:	232002.0.0
FILE NO.	Fig01-02_SludgeSedBasinLoc.mxd
DATE:	FEBRUARY 2016

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Section 2
Geologic and Hydrogeological Setting

Design of a groundwater monitoring system necessarily requires the identification and characterization of the uppermost aquifer underlying the basins. This section describes the regional and site-specific geologic and hydrogeological characteristics of the units underlying the basins and describes the nature of the uppermost aquifer.

2.1 Regional Geology and Hydrogeology

The Station is located in Halifax County, in the south-central portion of Virginia. This area is located in the Piedmont physiographic province. The Piedmont province is characterized by gently rolling topography and deeply weathered igneous and metamorphic rock that is termed residuum. In Halifax County, the residuum zone consists of the following three distinct layers:

- Soil, which consists of loose sand or sandy clay at the surface;
- Subsoil zone, which consists of a compact clay or mixture of grit and clay; and
- Saprolite, which consists of softened, weathered bedrock that retains much of its original structure and texture.

Residuum can be up to 60 feet (ft) thick in portions of Halifax County (LeGrand, 1960). Outcrops of the underlying bedrock are commonly restricted to stream valleys where the residuum has been removed by erosion. According to the Virginia Department of Mines, Minerals and Energy (VA DMME), the Station area is underlain by Paleozoic era metamorphic rocks. Specifically, the area is mapped as a mylonite (see Figure 2-1), a highly deformed metamorphic rock formed in-situ by the crushing and pulverizing of rock under extreme pressure along a shear zone. When deformation occurs over an extended period of time, mylonitic foliation may develop, making the rock difficult to distinguish from other types of foliated metamorphic rocks.

The region is drained by two major rivers each having an east to southeastward course. These are the Staunton River (Roanoke River), located north and east of the site, and the Dan River, located south of the site (Figure 2-2). Both rivers flow into Buggs Island Lake located approximately 27 miles southeast of the site.

Groundwater is present in both the residuum and within interconnected fractures in the underlying bedrock. In Halifax County, the size and number of fractures in bedrock decrease with depth. As a result, most groundwater occurs at a depth of less than 150 ft, much of it in the upper 30 ft of bedrock. Domestic water supplies in Halifax County are obtained from wells drilled into the fractured bedrock and well yields are a function of the number, size, and degree of interconnectedness of the fractures encountered. Drilled wells range in yield from less than one gallon per minute (gpm) to more than 100 gpm. Domestic wells generally range in depth from about 60 to 500 ft (LeGrand, 1960).

2.2 Site-Specific Geology

Subsurface investigations were conducted by Black & Veatch in 1989 and 1990 to evaluate the subsurface geology and hydrology of the site (Black & Veatch, (circa 1990)). Seventy-four borings were drilled to depths ranging from 13.5 to 103.5 ft below ground surface (bgs). Subsurface materials encountered during drilling consisted of a thick layer of saprolite overlying competent bedrock. The saprolite consisted of silty sands, silty clays, and clayey silts containing varying amounts of fine sand and mica. Bedrock was encountered in five of the 74 borings at depths ranging from 39.5 to 63.5 ft bgs. The locations of the five borings encountering bedrock, designated BV-10 through BV-13 and BV-27, with respect to the basins, are illustrated on Figure 2-3. The boring logs are included in Appendix A. According to the logs, bedrock is described as moderately to highly fractured granitic gneiss, hornblende gneiss, biotite gneiss, and quartz. As described in Subsection 2.1, small diameter rock samples obtained from a boring drilled into a mylonitic zone would be hard to differentiate from a gneiss in the field.

2.3 Description of Uppermost Aquifer

Groundwater occurs under unconfined water table conditions in the saprolite and underlying fractured bedrock. Depth to groundwater in existing monitoring wells surrounding the basins ranges from approximately 20 ft bgs on the upgradient side, to approximately 30 ft bgs on the downgradient side. A review of available historical water level data indicates that groundwater elevations have fluctuated between approximately 6 to 8 feet since 1994. Historical groundwater fluctuations have been influenced by extremely dry conditions observed in 1999, 2002, and 2008 and above-average rainfall conditions observed in 2004, 2006, and 2010. In general the magnitude of seasonal fluctuation is relatively small with slightly higher water levels in the spring and slightly lower water levels in the winter. The uppermost aquifer includes groundwater below the water table contained in the saprolite and interconnected water-producing fractures in the underlying bedrock.

In Halifax and Pittsylvania counties, the majority of water supplied to residential water wells is obtained at depths of less than 175 ft below grade, with more than 90 percent of the water occurring in the first 100 ft below the water table (LeGrand, 1960). Potable water is supplied to the Clover Power Station by two onsite potable drinking water wells, which are permitted by the Virginia Department of Health through Permit PWSID No 5083628 (VDH, 2006). The first well, Well M, is installed to a depth of 305 feet and yields about 55 gpm. The second well, Well N, is installed to a depth of 605 feet and yields about 5 gpm. Due to fewer water producing fractures with increased depth, the yield from the deeper well is only 10 percent of the yield from the shallower well. The lower boundary of the uppermost aquifer is defined as the point where interconnected water-producing fractures are no longer present, or the fractures are not interconnected or too small to produce a usable quantity of water.

2.4 Groundwater Flow Direction and Rate

Dominion currently monitors groundwater quality at the Station pursuant to a Virginia Pollutant Discharge Elimination System (VPDES) Permit (No. 0083097). Eight of the wells (PW-1 through PW-8) monitor groundwater quality in the vicinity of the basins (Figure 2-4). Water level measurements collected from these wells since 1994 have consistently demonstrated overall flow beneath and in the vicinity of the basins to be northeastward, toward the Roanoke River. There do not appear to be significant seasonal changes in the groundwater flow direction. Water levels were recently measured in these eight wells, plus two newly installed wells (PW-12 and PW-13), on February 8, 2016. Figure 2-5 illustrates the configuration of the water table generated from these measurements. Groundwater flow, based on equipotential contouring, is to the northeast, consistent with previous interpretations.

Saprolite is the product of *in-situ* chemical weathering of bedrock and as such, generally retains the original structure of the parent bedrock from which it was derived. Groundwater flow within the saprolite is controlled by foliation planes and joints within the weathered material. The rate of groundwater movement in saprolite is controlled by the permeability of foliation planes and joints and by local hydraulic gradients. The rate of groundwater flow, or seepage velocity, was estimated using the Darcy equation as follows:

$$V = K\, i/n_e$$

Where V = Seepage velocity

K = hydraulic conductivity

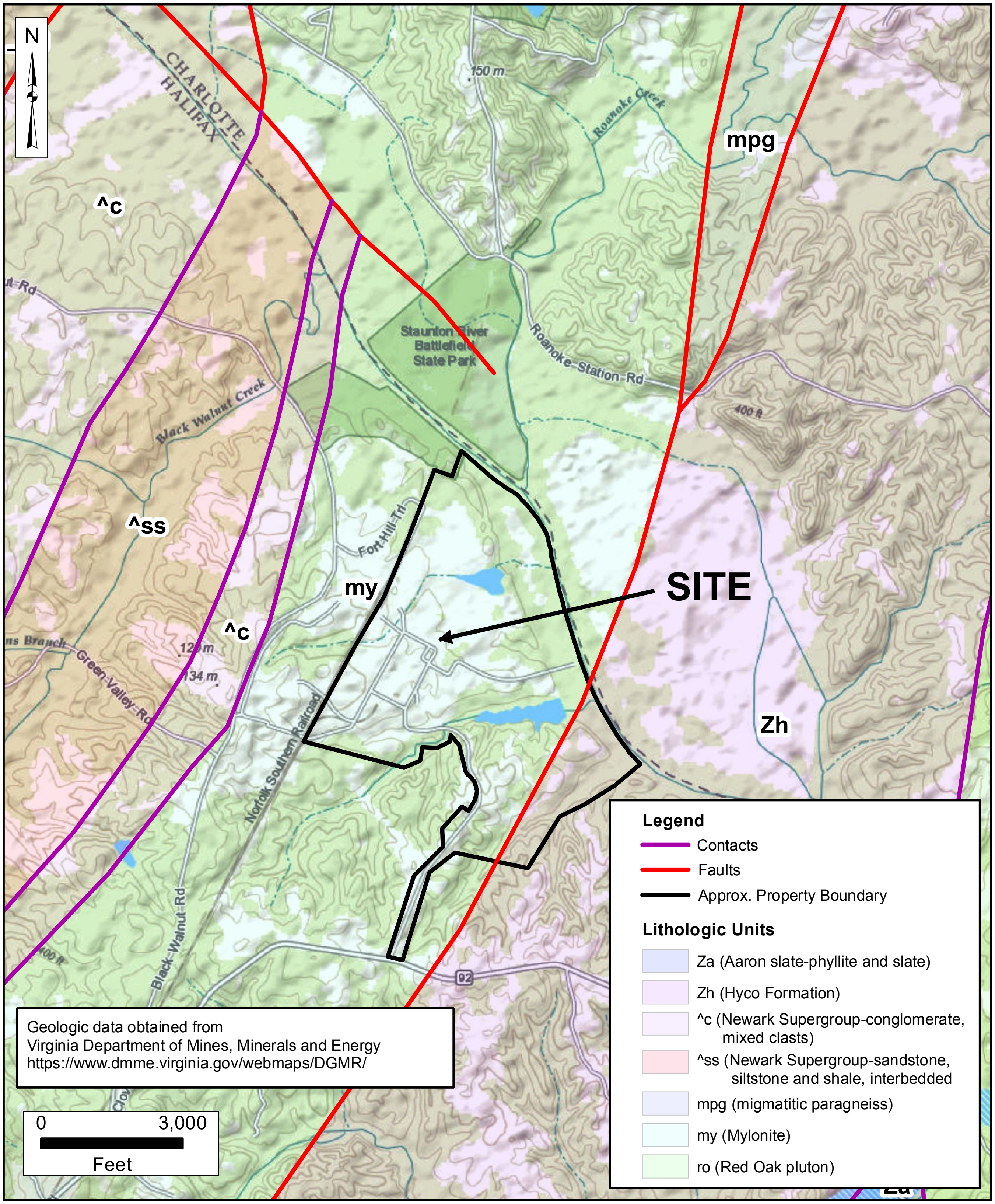
i = hydraulic gradient

n_e = effective porosity

Aquifer hydraulic conductivities were determined through the performance of single-well aquifer tests, commonly referred to as slug tests, in monitoring wells PW-2, PW-3, PW-4, PW-5, PW-6, PW-12, and PW-13. The tests were conducted by producing a rapid ("instantaneous") change in the water level within the well and recording the recovery of the water level over time. The instantaneous change was produced by submerging a solid plastic rod ("slug") into the groundwater within the well, allowing the water level to return to an equilibrium water level (Falling Head Test), then rapidly withdrawing the slug from the well (Rising Head Test). The recovery of the water level was recorded using a down-well pressure transducer connected to a programmable data logger. Multiple tests were conducted on each well. The data were downloaded to a computer for processing and analysis. AQTESOLV™ software was used to evaluate the slug test data. Hydraulic conductivities were estimated using the Bouwer and Rice method (Bouwer and Rice, 1976; Bouwer, 1989). Appendix B provides the slug test data and results of the hydraulic conductivity calculations performed on the wells. The estimated hydraulic conductivity values calculated for each well are summarized in Appendix C.

The hydraulic gradient is calculated by dividing the difference in elevation between two points drawn parallel to the direction of flow by the horizontal distance between the points. Using the February 8, 2016, water level measurements, an average hydraulic gradient of 0.0165 ft/ft is calculated (see Appendix C). Effective porosity is typically estimated and based on the materials located adjacent to the screened portion of the monitoring wells. According to the boring logs prepared for monitoring wells located in the vicinity of the basins, the geologic materials can be divided into three general groups of saprolitic soils; silty clay/clayey silt, silty sand, and silty sand/weathered rock (see Appendix C). Estimates of the effective porosity values for these materials were obtained from the *Standard Handbook for Solid and Hazardous Waste Facility Assessment* (Sara, Martin N., 1994). Although these values are from deposited unconsolidated materials and not necessarily from chemically weathered saprolite, they were useful in assessing predicted groundwater flow rates through the saprolite. Seepage velocity calculations are provided in Appendix C.

According to these calculations, groundwater flow rates in the vicinity of the basins is highly variable. Groundwater flow in the fine-grained silty clay to clayey silt materials (*i.e*. PW-2 and PW-4) is generally less than 10 feet per year. Groundwater flow in the silty sands (*i.e*., PW-3, PW-12 and PW-13) ranges from about 20 to 30 feet per year. Wells screened within silty sand and weathered rock (PW-5 and PW-6) show the highest seepage velocities, ranging from approximately 190 to 750 feet per year.



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Greenville, SC 29615-3535
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FIGURE 2-1
LOCAL GEOLOGY

Drawn By:	TLH
Checked By:	LMC
Approved By:	GT
Project No.:	232002.0.0
Date:	JANUARY 2016

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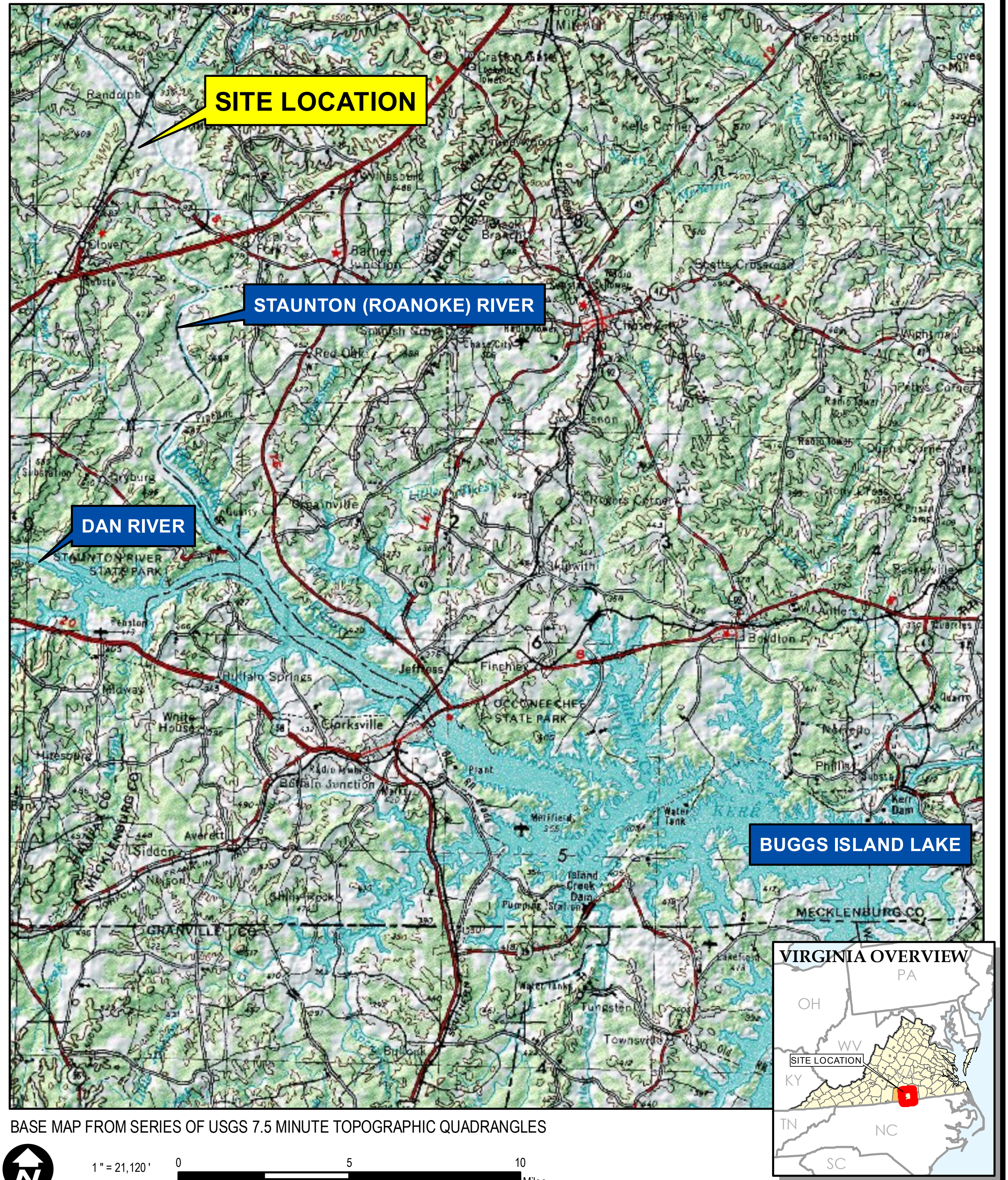

BASE MAP FROM SERIES OF USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLES

1 " = 21,120 '
1:253,440

0 5 10 Miles

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FIGURE 2-2
REGIONAL DRAINAGE FEATURES

DRAWN BY:	AMF
APPROVED BY:	JMK
PROJECT NO:	232002.0.0
FILE NO.	Fig02-02_RegDrainage.mxd
DATE:	JANUARY 2016

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LEGEND

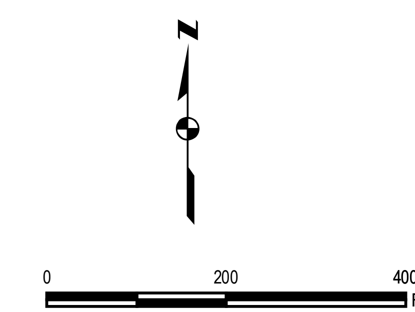
- SELECT BV BORING LOCATIONS
- MONITORING WELL LOCATIONS
- SLUDGE SEDIMENTATION BASIN

NOTES:

1) WELLS WERE SURVEYED BY TIMMONS GROUP.

2) BV BORING LOCATION COORDINATES BY BLACK & VEATCH ENGINEERS & ARCHITECTS.

2) AERIAL PHOTOGRAPH SOURCE: ESRI WORLD IMAGERY.



PROJECT:	**DOMINION RESOURCES SERVICES, INC.** **CLOVER POWER STATION, VIRGINIA**
SHEET TITLE:	**SELECT BV BORING LOCATIONS** **(BV-10, 11, 12, 13, & 27)**

DRAWN BY: AMF	SCALE: 1: 2,567	PROJ. NO.	232002.0.0
CHECKED BY: LMC		FILE NO.	Fig02-03_BVBorings.mxd
APPROVED BY: GET	DATE PRINTED:	**FIGURE 2-3**	
DATE: MARCH 2016			

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Coordinate System: NAD 1983 StatePlane Virginia South FIPS 4502 Feet (Foot US)
Map Rotation: 0

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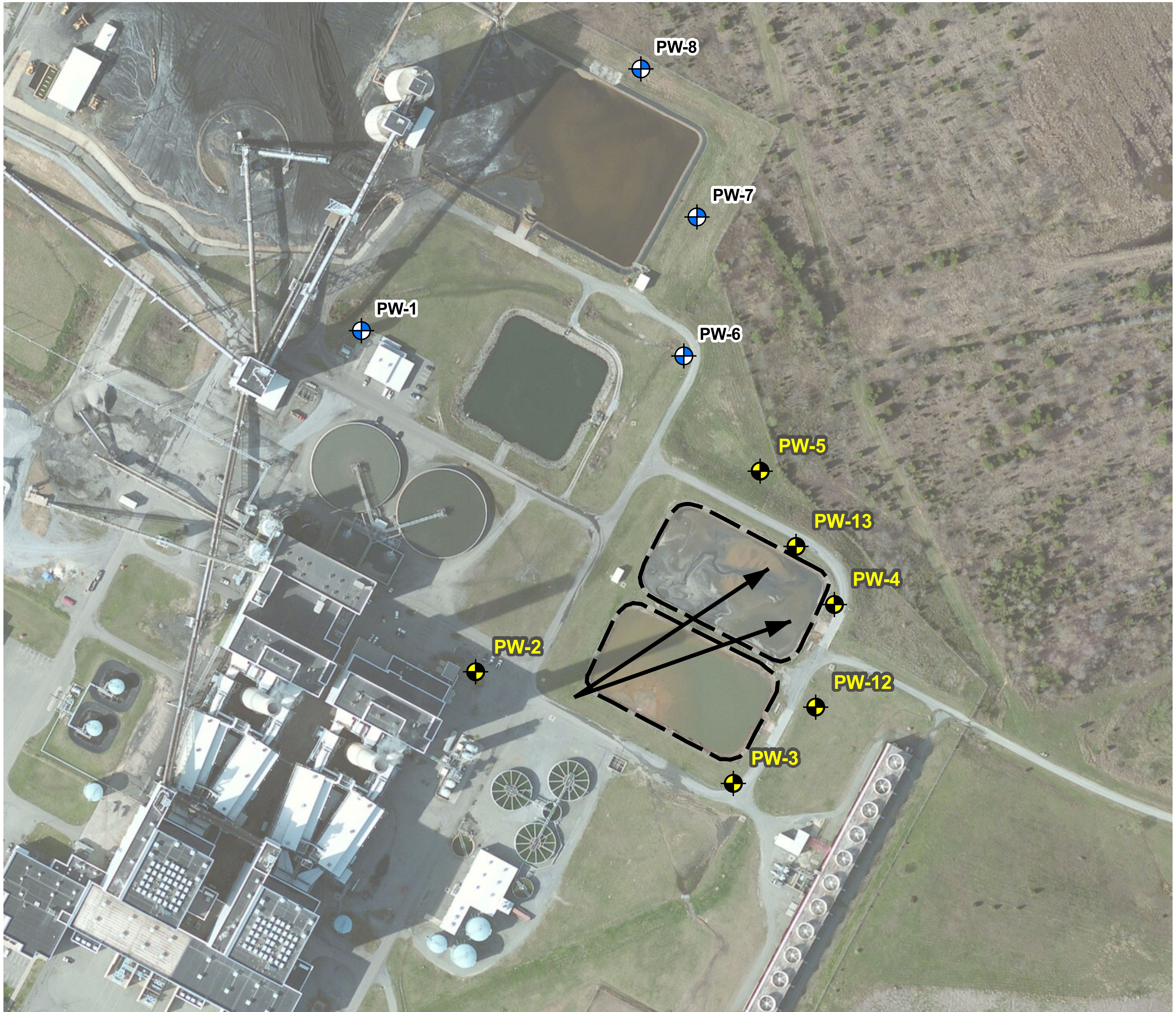

LEGEND

- MONITORING WELL TO BE SAMPLED
- MONITORING WELL
- SLUDGE SEDIMENTATION BASIN
- HISTORICAL DIRECTION OF GROUNDWATER FLOW

NOTES:

1) WELLS WERE SURVEYED BY TIMMONS GROUP.

2) AERIAL PHOTOGRAPH SOURCE: ESRI WORLD IMAGERY.

N

0 250 500 Feet

PROJECT:	DOMINION RESOURCES SERVICES, INC. CLOVER POWER STATION, VIRGINIA		
SHEET TITLE:	SLUDGE SEDIMENTATION BASINS GROUNDWATER MONITORING NETWORK		
DRAWN BY: RSW	SCALE: 1: 2,400	PROJ. NO. 232002.0.0	
CHECKED BY: LMC		FILE NO. Fig2-4_SludgeSedBasin.mxd	
APPROVED BY: GET	DATE PRINTED:	FIGURE 2-4	
DATE: FEBRUARY 2016			

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Map Rotation: 0

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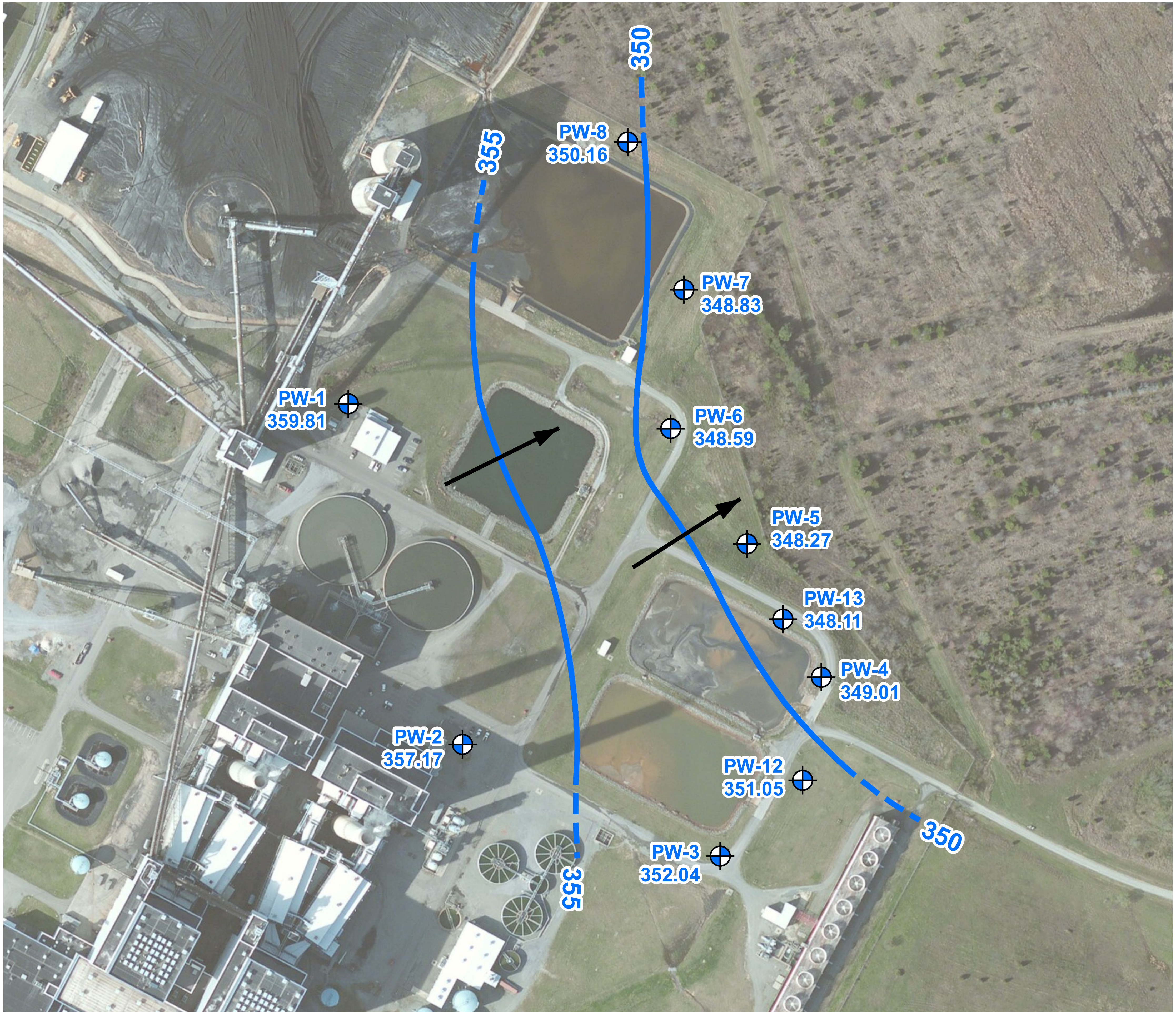

LEGEND

MONITORING WELL

348.83 WATER ELEVATION (FT MSL)

WATER TABLE ELEVATION IN FEET ABOVE MEAN SEA LEVEL (5' CONTOUR INTERVALS). DASHED WHERE INFERRED.

GROUNDWATER FLOW DIRECTION

NOTES:

1) WELLS WERE SURVEYED BY TIMMONS GROUP.

2) AERIAL PHOTOGRAPH SOURCE: ESRI WORLD IMAGERY.

N

0 200 400 Feet

PROJECT: DOMINION RESOURCES SERVICES, INC. CLOVER POWER STATION, VIRGINIA		
SHEET TITLE: WATER TABLE CONFIGURATION FEBRUARY 8, 2016		
DRAWN BY: AMF	SCALE: 1: 2,400	PROJ. NO. 232002.0.0.1
CHECKED BY: RAM		FILE NO. Fig2-5_WTConfig_20160208.mxd
APPROVED BY: GET	DATE PRINTED:	FIGURE 2-5
DATE: MARCH 2016		

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Coordinate System: NAD 1983 CORS96 StatePlane Virginia South FIPS 4502 Ft US (Foot US)
Map Rotation: 0

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Section 3
Groundwater Monitoring System

As specified in Section 257.91 of the CCR Rule and 9VAC20-81-250(A) of the VSWMR, the owner or operator of a CCR unit must install a groundwater monitoring system that consists of a sufficient number of wells, installed at appropriate locations and depths, to yield groundwater samples from the uppermost aquifer that accurately represent groundwater quality both upgradient and downgradient of the units. The CCR Rule also allows owners or operators of multiple CCR units to install a multiunit groundwater monitoring system instead of installing separate groundwater monitoring systems for each unit. Based on the proximity, orientation, and design of the two basins and the hydrogeologic characteristics of the uppermost aquifer, a multiunit groundwater monitoring system is proposed to monitor groundwater quality upgradient and downgradient of both basins.

Section 257.91 of the CCR Rule and 9VAC20-81-250(A) of the VSWMR state that the groundwater monitoring system must yield samples from the uppermost aquifer that accurately represent the quality of background groundwater that has not been affected by leakage from a CCR unit and represents the quality of groundwater passing the waste boundary of the unit. The monitoring well network described Section 3.1 has been designed to meet the performance standards specified in Section 257.91 of the CCR Rule and 9VAC20-81-250(A)(3). Should a monitoring well need to be replaced or abandoned or if additional monitoring wells need to be installed, the procedures for these activities are provided in Sections 3.2 through 3.5.

3.1 Existing Monitoring System

The multiunit groundwater monitoring system for the basins consists of a total of six monitoring wells installed into saprolite both upgradient and downgradient of the basins. PW-2 is installed upgradient of the basins and monitors background quality in the uppermost aquifer. PW-3 was initially installed as a downgradient well by Black & Veatch in about 1990; however, interpretation of historical groundwater flow directions suggests that PW-3 may be cross-gradient of the basins and not downgradient. The remaining four wells (PW-4, PW-5, PW-12, and PW-13) are installed downgradient of the basins and monitor the quality of groundwater in the uppermost aquifer passing the waste boundary of the basins. Wells PW-2, PW-3, PW-4 and PW-5 were installed as part of the existing VPDES compliance monitoring network for the Station's wastewater treatment facilities. Wells PW-12 and PW-13 were recently added to provide additional monitoring of groundwater passing the waste boundary of the basins. Figure 2-4 illustrates the locations of the six monitoring wells with respect to the basins and the historical direction of groundwater flow (determined during routine VPDES monitoring). Figure 3-1 is a cross-sectional view through the basins illustrating the position of the water table and two monitoring wells (one upgradient and one downgradient) with respect to the bottom of the basins and projected top of bedrock.

Boring logs and construction diagrams for the six monitoring wells and the other four wells used to determine the historical direction of groundwater flow in the vicinity of the basins are provided in Appendix D. Table 3-1 summarizes well construction details for the six monitoring wells.

3.2 New Well Installation

In the event that a well requires replacement due to non-performance issues, notification will be made to the VDEQ within 30 days of recognizing non-performance. The notification will include a site plan depicting the proposed replacement well location for VDEQ review. The replacement well(s) will be completed prior to the next regularly scheduled groundwater sampling event unless the VDEQ grants an extension. Upon completion, new wells will be equipped with dedicated bladder pumps for future sampling. Drilling and well installation will be conducted as described in the following Subsections.

3.2.1 Drilling Methods

Monitoring wells will be installed in boreholes that will be advanced using rotary or sonic drilling techniques. The borehole will have a minimum diameter of six inches in rock and the borehole drilling tools with have a minimum diameter of six inches in unconsolidated materials. Drilling fluids will consist of water and/or compressed air. Water used as a drilling fluid will originate from a potable source and air will be forced through a filter prior to being placed in the borehole. If necessary, drilling mud may be utilized to lubricate drilling tools and/or to maintain an open borehole without casing or augers.

3.2.2 Soil and Rock Sampling Techniques

Soil samples will be collected using a two-inch diameter split barrel soil sampler that is advanced in conjunction with standard penetration testing at various intervals. In boreholes drilled by sonic methods, soil samples will be collected in a four-inch diameter sampling tube and extruded at the drill site for visual classification. Each borehole will be logged throughout its entire length. The soils will be visually classified in accordance with the Unified Soil Classification System.

3.2.3 Well Construction Materials and Placement

Well construction materials will consist of:

- two-inch or four-inch diameter threaded and flush-jointed PVC screen and riser pipe;
- locking protective steel covers (minimum three-inch diameter and minimum five feet long);
- inert silica sand;
- bentonite pellets, chips, and/or high solids bentonite grout;
- neat cement; and
- concrete

Each of these materials will be used during well construction as described in the following paragraphs. They have been selected based on function and durability and they are considered state of practice for monitoring wells installed at similar facilities.

Once the borehole has been drilled to the desired depth, well screen and casing will be placed in the borehole. Monitoring wells will not be installed through CCR and the well screen will be located completely within the saturated zone. Well screens will be a maximum length of 10 feet and have 0.01-inch machined slots. The base of the screen will be fitted with a threaded PVC cap. The slot size has been selected to accommodate the filter pack to be placed in the annular space. These materials are normally used in this type of construction and no degradation due to intense well development is expected. It is understood that any non-functioning well or wells not installed at proper screened intervals will be replaced and/or abandoned.

The filter pack will consist of inert silica sand and it will be of sufficient size to prevent large quantities of the filter pack material from entering the well through the screen slots. The sand pack will extend from a minimum of six inches below the bottom of the well screen to approximately two feet above the top of the well screen.

A hydrated bentonite seal will be placed in the annular space above the sand pack and it will have a minimum thickness of two feet. The remainder of the annular space will be grouted from the top of the bentonite seal to within three feet of the ground surface. Grout may consist of neat cement, cement/bentonite slurry or bentonite clay grout. Any grout that is placed in the well annulus will be placed from the bottom-up by pumping the grout into the annulus through a tremie pipe. Grout will be placed in stages if the seal height is to exceed 50 feet.

At the surface, a locking protective steel casing that has a minimum diameter of three inches and a minimum length of five feet will be placed over the PVC well casing. The protective casing will extend a minimum of two-feet below the ground surface. Concrete will be placed above the annular seal materials and will extend into a surface apron that has the nominal dimensions of two-feet by two-feet by four-inches thick. The concrete will be placed around the locking protective cover and it will be finished to slope away from the well's casing.

Concrete filled bollards will be installed around the completed well in areas where such protection is deemed to be necessary.

3.2.4 Well Development

Following installation, new wells will be developed to remove particulates that are present in the well casing, filter pack, and adjacent aquifer matrix due to construction activities so that natural hydraulic conditions are restored and representative formation water quality samples can be obtained. Development of new monitoring wells will be performed at least 24 hours after well construction. Turbidity is used as a preliminary indicator parameter of successful well development and completion. The well development process is deemed complete as the well begins to yield a visually sediment free water sample and turbidity values have stabilized and/or achieved a value of 10 NTU or less.

Wells may be developed with a well development pump, or other approved method. Conventional monitoring wells are generally developed by pumping. A well development pump is raised in increments across the screened interval and pumped at the highest sustainable yield until a visually clear sample is produced. In general, a minimum of 10 casing volumes are removed. If there is insufficient yield or insufficient water depth, the well is allowed to recover before it is subsequently pumped.

Samples withdrawn from the Facility's monitoring wells should be clay- and silt-free; therefore, wells may require redevelopment from time to time based upon observed turbidity levels during sampling activities. If redevelopment of a monitoring well is required, it will be performed and documented in a manner similar to that used for a new well.

3.2.5 Equipment Decontamination

If decontamination of drilling, sampling, or development equipment is necessary during the monitoring well installation work, the following methods will be employed:

- Heavy Equipment: Drill rig, auger flights, drill rod, water swivels, casing materials, wrenches, and other heavy equipment may be cleaned prior to drilling at each location by steam cleaning and/or washing with laboratory grade soap (*e.g*. Liquinox) and tap water. Brushing may be required to remove hard or caked on material.
- Sampling Equipment: Sampling equipment (split spoons, Shelby tubes etc.) used to collect soil samples during drilling shall be decontaminated between each sample as follows:
  - wash with laboratory grade soap and tap water;
  - rinse thoroughly with tap water;
  - rinse a minimum of three times with distilled or deionized, organic free water;
  - air dry.

3.2.6 Investigation Derived Waste (IDW) Management

Soil cuttings, drilling fluids, development water, and decontamination fluids will be placed in 55-gallon drums, roll-offs, or other appropriate containers at the well site and/or decontamination pad and subsequently managed in accordance with the VDEQ's Investigative Derived Waste Disposal Policy. Solid wastes, such as waste paper, used personnel protective equipment, and general trash will be bagged and placed into on-site dumpsters for transport to a permitted waste management facility. Soil cuttings from monitoring well installation will be considered a solid waste and will be transported to a permitted waste management facility for disposal. Liquid waste (*i.e*., purge water, development water, etc.) derived from the installation and sampling of monitoring wells will be discharged into the basins and managed with other process wastewater.

3.2.7 Surveying

Upon completion of monitoring well installation, the ground surface and/or concrete pad and top of well casing will be surveyed for x, y and z coordinates. These measurements will be within ± 0.5 feet on the horizontal plane and ± 0.01 feet vertically. The survey will be completed using a permanent and established benchmark and/or a global positioning system and will be conducted by a licensed or otherwise certified land surveyor.

Monitoring wells will be surveyed after installation. Survey information to be documented will include, at a minimum the following:

- ground surface and/or concrete apron elevation, specified to within 0.01-foot;

- top of monitoring well casing elevation, specified to within 0.01-foot;
- top of protective steel casing elevation, specified to within 0.01-foot.

3.3 Monitoring Well Abandonment

If a monitoring well is deemed unusable and needs to be permanently abandoned, a Virginia-licensed well driller will be contracted to overdrill and remove the well in accordance with the following procedures:

- Obtain VDEQ approval prior to the removal of any well(s) from the active monitoring program.
- Remove protective outer casing and concrete pad.
- If possible, pull out well casing and screening.
- Overdrill the well using a hollow-stem auger drill bit that exceeds the diameter of the original borehole. The drill bit shall be advanced to the base of the well to remove the casing and annular materials while ensuring that the bit is centered throughout the overdrilling process.
- Clean the borehole, as needed, to remove fragments of the well casing and screen that may have broken off during overdrilling.
- Upon removal of the casing, well screen, and annular materials, grout the resulting borehole with a neat cement, a bentonite-cement grout slurry, or bentonite clay grout emplaced by a tremie pipe starting at the bottom of the borehole and continuing upward to within three feet of ground surface. The top three feet of the borehole shall be abandoned by adding and compacting native soils.
- Note the date of well abandonment and drilling firm completing the abandonment on the well log.
- Certify well abandonment by a qualified professional engineer and submit the certification documentation to VDEQ within 44 days following well abandonment activities.

3.4 Certification

A certification statement, prepared by a qualified professional engineer, will be prepared documenting that the construction of new monitoring wells or abandonment of monitoring wells has been conducted in accordance with this GWMP. This certification shall occur within 44 days of completing the well construction or abandonment process.

3.5 Documentation

Documentation of future well construction or abandonment will be in accordance with the VSWMR. A boring log, well construction log, groundwater monitoring network map, and installation or abandonment certification report will be submitted to the VDEQ within 44 days following the completion of installation and/or abandonment activities. The well installation and/or abandonment report will be certified by a qualified professional engineer in accordance with the VSWMR. Well installation and abandonment documents will be retained on file until the basins are released from post-closure monitoring requirements.

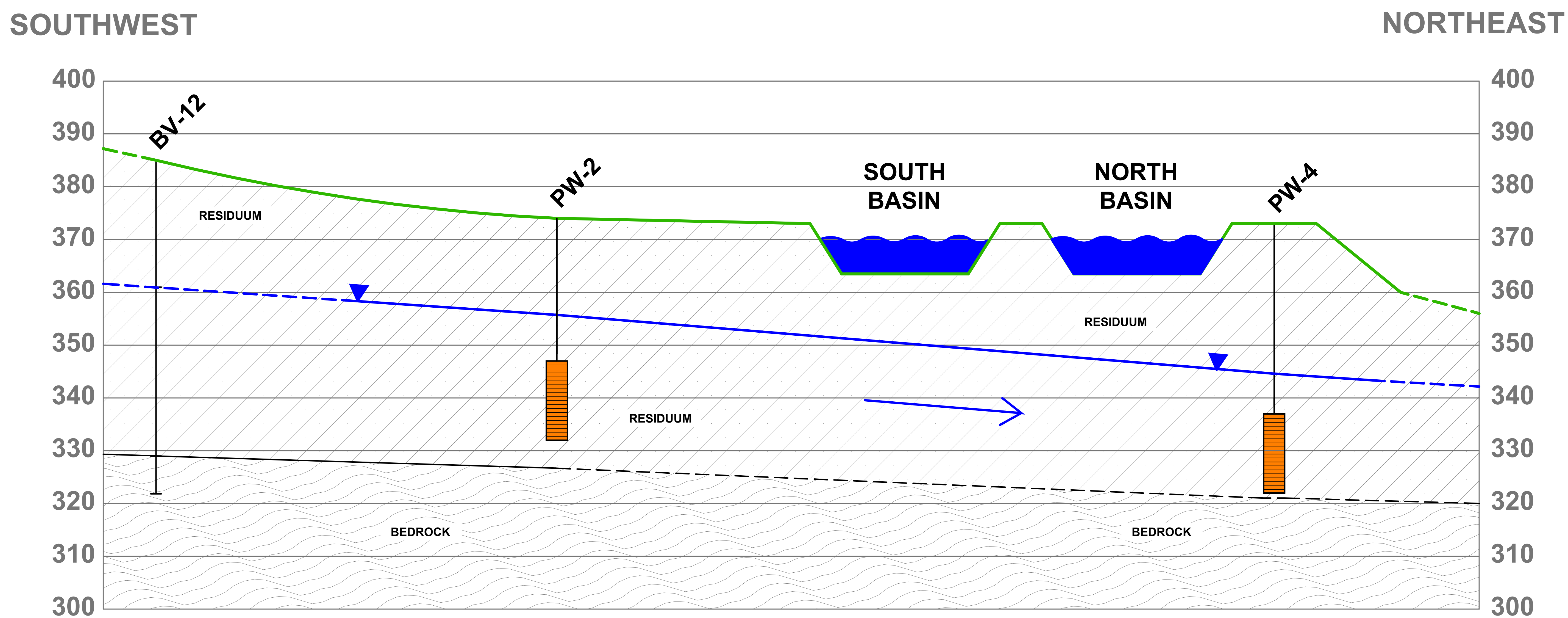
Well installation or abandonment activities will be documented in the field by a technician that monitors the drilling, installation, and abandonment procedures. Field documented information will, at a minimum, include the following:

- Well ID;
- date/time of construction or abandonment;
- drilling method and drilling fluid used;
- depth to water and depth of well
- bore hole and well casing diameter;
- casing materials;
- screen materials and diameter;
- screen length and slot size;
- filter pack material and mesh size;
- filter pack placement method and amount used;
- sealant materials and amount used ;
- sealant placement method;
- surface seal design and construction;
- well development procedure;
- type of protective well cap;
- Name and address of drilling firm performing installation or abandonment;
- Disposition of IDW.

Table 3-1
Monitoring Well Details

WELL ID	POSITION TO BASINS	NORTHING	EASTING	TOP OF PVC CASING ELEVATION	TOP OF STEEL PROTECTIVE CASING ELEVATION	CONCRETE PAD ELEVATION	WELL SCREEN INTERVAL
PW-2	Upgradient	3476235.197	11423449	377.10	377.87	375.32	27 – 42
PW-3	Downgradient/ Cross-Gradient	3476014.596	11423958	376.22	376.83	374.04	30 – 45
PW-4	Downgradient	3476368.566	11424159	375.88	376.73	373.90	36 – 51
PW-5	Downgradient	3476632.886	11424012.1	358.33	358.79	356.48	24 – 39
PW-12	Downgradient	3476632.886	11424121.6	371.93	372.26	369.12	26.8 – 41.8
PW-13	Downgradient	3476483.437	11424082.9	376.56	376.82	373.66	35 – 50

(1) Elevations are measured in ft above mean sea level (amsl). Depths are measured in ft bgs.

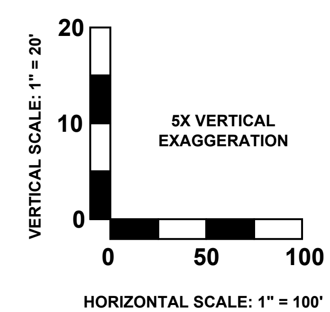


LEGEND

GROUNDWATER FLOW DIRECTION

PW WELL WITH SCREEN

NOTE:
WATER LEVELS MEASURED NOVEMBER 3, 2015



PROJECT: DOMINION RESOURCES SERVICES, INC. CLOVER POWER STATION, WEST VIRGINIA	
TITLE: HYDROGEOLOGIC CROSS SECTION	
DRAWN BY: AMF	PROJ NO.: 230765.0.0
CHECKED BY: LMC	FIGURE 3-1
APPROVED BY: GET	
DATE: JANUARY 2016	
TRC	30 Patewood Drive, Patewood Plaza One, Suite 300, Greenville, SC 29615, Phone: 864.281.0030
FILE NO.:	HydroXSect_20160115.dwg

11x17 --- ATTACHED XREF'S: --- ATTACHED IMAGES:
DRAWING NAME: J:\CAD\Dominion\Clover\ HydroXSect_20160115.dwg --- PLOT DATE: February 28, 2017 - 8:39AM --- LAYOUT: Layout1

Section 4
Groundwater Monitoring Program

Dominion will implement a GWMP that combines monitoring and reporting elements of the CCR Rule and the VSWMR. VDEQ will permit the facility under the Modified Assessment Monitoring Program, as outlined in the VSWMR, only.

4.1 Groundwater Monitoring Constituents

Under the CCR Rule, groundwater monitoring constituents are divided into two categories; detection and assessment. Under the VSWMR, the two groundwater monitoring categories are first determination and Phase II. Groundwater monitoring conducted under this GWMP combines the parameters of these two individual programs into a single list called the Modified Assessment Monitoring Program. The analytical constituents for the Modified Assessment Monitoring Program include those constituents listed in Appendix III and Appendix IV of Part 257 of the CCR Rule and VSWMR Table 3.1 Column A and Column B inorganic constituents. In addition to the above constituents, the Modified Assessment Monitoring Program parameter list includes existing constituents for the VPDES Clover Power Station Wastewater Treatment Facilities GMP. The Modified Assessment Monitoring Program constituents are provided in Table 4-1 of this GWMP.

All sample laboratory preparations and analyses will be performed by a Virginia Environmental Laboratory Accreditation Program (VELAP) certified laboratory. During well purging, groundwater samples will be field analyzed for the following parameters to determine well stabilization:

- pH (standard units)
- Specific conductivity (µS/cm)
- Temperature (Celsius)
- Turbidity (ntu)

Under the Modified Assessment Monitoring Program, groundwater samples will be analyzed for the constituents in Table 4-1.

Pursuant to Section 257.93(i), "total recoverable metals" will be measured for the metal constituents listed in Table 4-1. A summary of the laboratory analytical methods, sample hold times, container types, container volumes, and sample preservatives, is presented in Table 4-2. For each analytical parameter that has a Maximum Contaminant Level (MCL) value under the Federal National Primary Drinking Water Regulations, the quantitative analytical detection limit will be at or below the corresponding MCL.

4.2 Baseline Sampling

As specified in Section 257.90 of the CCR Rule for existing CCR surface impoundments, a minimum of eight independent samples from each upgradient and downgradient well must be collected and analyzed for the constituents listed in Appendix III and Appendix IV to Part 257 of the CCR Rule by no later than October 17, 2017. Appendix III and Appendix IV parameters are provided in Table 4-1. The purpose of this sampling is to establish baseline groundwater quality conditions in each of the monitoring wells included in the groundwater monitoring system for the basins. Baseline data collected from upgradient monitoring well PW-2 will be statistically evaluated as described in Section 6 to establish background groundwater quality conditions for the basins. Sampling of the six monitoring wells identified in Section 3 will be initiated and conducted on an approximately quarterly basis, beginning in the fourth quarter of 2015. If statistical evaluation of these data determine that additional samples are required in order to establish baseline conditions, then additional sampling will be performed.

4.3 Groundwater Protection Standards

Upon completion of baseline sampling, Dominion will establish Groundwater Protection Standards (GPS) for each detected Modified Assessment Monitoring constituent (Table 4-1). The GPS shall be established as follows:

- For constituents for which an MCL has been promulgated under Section 1412 of the Safe Drinking Water Act (40 CFR Part 141), the GPS will be the MCL for that constituent;
- For constituents for which MCLs have not been promulgated, the background concentration will be the GPS; or
- For constituents for which the background level is higher than the MCL, the background concentration will be the GPS, as approved by the VDEQ.

The established GPS will be included in the annual monitoring reports required by the VSWMR and the CCR and in the corrective action report (if required). The MCL-based GPS will be updated immediately upon USEPA's promulgation of new or revised MCLs. The background-based GPS will be updated every 2 years such that the eight most recent background well sampling results shall replace the oldest eight background well sampling results as described in Section 6.

4.4 Modified Assessment Monitoring Program

Once sufficient baseline data are available, and GPS for each constituent in Table 4-1 has been established, Modified Assessment Monitoring will be initiated on a semiannual basis. Under Modified Assessment Monitoring, groundwater samples from each upgradient and downgradient well will be collected and analyzed for the constituents listed in Table 4-1. Within 30 days of receipt of the analytical results, the data will be evaluated as described in

Section 6 to determine if there has been a statistically significant increase (SSI) over GPS for any Table 4-1 constituent in any of the downgradient monitoring wells. If an SSI over GPS is identified, the well or wells will be resampled within the 30 day verification period after the laboratory data is received to verify the results. If the SSI over GPS is verified as described in Section 6, VDEQ will be notified within 14 days of the end of the 30-day verification period and the notification will include a statement that within 90 days Dominion will either provide evidence that a source other than the basins was responsible for the exceedance (Section 257.94(e)(2) of CCR rule), collect a total of four independent samples within the semiannual compliance period for statistical comparison to MCL-based GPS or potential revision of a background-based GPS, or initiate an assessment of corrective measures in accordance with Section 257.96 of the CCR Rule. Notification will be sent to VDEQ providing either the data supporting an alternate source determination, or notification of the corrective measures assessment.

4.5 Alternate Source Demonstration

In accordance with the CCR and VSWMR, the owner or operator may demonstrate that a source other than the CCR unit(s) caused the detection of a constituent or parameter at a concentration greater than facility background or greater than a GPS, or that a statistically significant detection resulted from an error in sampling procedures, analysis, statistical procedures, or natural variation in groundwater quality. The Alternate Source Demonstration (ASD) under the Modified Assessment Monitoring Program must be submitted to and approved by the VDEQ within 90 days of confirming the statistical exceedance to avoid advancing into the Corrective Action Program.

If the ASD is approved by the VDEQ, the operator may continue with the CCR Unit Monitoring Program. If the ASD is not approved by the VDEQ, the operator will initiate the Corrective Action Program by undertaking characterization and assessment activities.

Table 4-1
Constituents for Modified Assessment Monitoring Program

CCR Appendix III and Appendix IV to Part 257		
Antimony	Arsenic	Barium
Beryllium	Boron	Cadmium
Calcium	Chloride	Chromium*
Cobalt	Fluoride	Lead
Lithium	Mercury	Molybdenum
pH	Selenium	Sulfate
Thallium	Total dissolved solids (TDS)	Radium 226 and 228 combined
VPDES Clover Power Station Wastewater Treatment Facilities Groundwater Monitoring Plan Water Quality Pollutants (Permit No. VA0083097)		
Manganese	Total Organic Carbon (TOC)	Alkalinity
Iron	Hardness	Sodium
Virginia Solid Waste Management Regulations Table 3.1 Column A Constituents		
Copper	Nickel	Silver
Vanadium	Zinc	
Virginia Solid Waste Management Regulations Table 3.1 Column B Metals		
Cyanide	Sulfide	Tin

- **Chromium results must be reported as total, and also include speciation of Hexavalent Chromium.**

Table 4-2
Sample Preservation and Analytical Requirements

CONSTITUENT	ANALYTICAL METHOD	SAMPLE HOLD TIME	CONTAINER TYPE AND VOLUME	SAMPLE PRESERVATIVE
Total Metals				
Boron	SW6010C	6 months	500 mL plastic or glass	Nitric acid (HNO_3) (pH<2)
Antimony Arsenic Barium Beryllium Cadmium Calcium Chromium, total Cobalt Copper Iron Lead Lithium Manganese Molybdenum Nickel Selenium Silver Sodium Thallium Tin Vanadium Zinc	SW 6020A	6 months	500 mL plastic or glass	HNO_3 (pH<2)
Chromium, hexavalent	SW 7196A	24 hours	500 mL plastic or glass	None
Mercury	SW 7470A	28 days	500 mL plastic or glass	HNO_3 (pH<2)
Wet Chemistry				
Alkalinity	EPA 310.2	14 days	250 mL plastic or glass	None
Chloride	EPA 300.0	28 days	250 mL plastic or glass	None
Cyanide	SW 9012B	14 days	250 mL plastic or glass	NaOH
Hardness	EPA 130.1	6 months	250 mL plastic or glass	HNO_3 (pH<2)
Sulfate	EPA 300.0	28 days	250 mL plastic or glass	None
Sulfide	SW 9215B	7 days	250 mL plastic or glass	NaOH + zinc acetate
Fluoride	EPA 300.0	28 days	250 mL plastic or glass	None
TDS	SM 2540C	7 days	250 mL plastic or glass	None

Table 4-2
Sample Preservation and Analytical Requirements

CONSTITUENT	ANALYTICAL METHOD	SAMPLE HOLD TIME	CONTAINER TYPE AND VOLUME	SAMPLE PRESERVATIVE
TOC	EPA 9060A	28 days	3 x 40 mL amber VOA	H_2SO_4
Radiological				
Radium 226 and 228 combined	SW 9315/9320	6 months	1,000 mL plastic or glass	HNO_3 (pH<2)
Field Analytical				
pH	SM4500 H + B or equivalent	None	Not applicable	None
Specific Conductance	SM2510B or equivalent	None	Not applicable	None
Temperature	SM2550B or equivalent	None	Not applicable	None
Turbidity	EPA 180.1 or equivalent	None	Not applicable	None

SW = SW-846; Test Methods for Evaluating Solid Waste: Physical/Chemical Methods Compendium.
SM = Standard Methods for the Examination of Water and Wastewater.

Section 5
Sampling and Analysis Procedures

Specific requirements for groundwater sample collection and analysis under the CCR Rule are described in Section 257.93 of the CCR Rule. This section of the GWMP describes the procedures that will be implemented at the Station basins for the collection and analysis of groundwater samples.

The following factors and procedures shall be considered and/or implemented in planning and conducting sampling operations. These factors and procedures must be considered in light of the specific objectives and scope of the monitoring activities.

- Safety of sampling personnel
- Safety briefing process
- Selection and proper preparation of sampling equipment
- Selection of parameters to be measured and evaluation of sample fractions to be analyzed
- Required sample volumes
- Selection and proper preparation of sample containers
- Sample preservation
- Sample holding times
- Sample handling
- Special precautions for trace contaminant sampling
- Sample identification
- Collection of auxiliary data
- Transportation and shipping of samples
- QA and QC
- Sample chain-of-custody

Specific procedures for collecting groundwater samples to monitor water quality outlined in this GWMP are based on established and accepted procedures. Procedures developed by the USEPA are used wherever applicable. Proper sampling techniques are necessary to assure that samples are representative and that the sample is neither altered nor contaminated by the sampling procedure.

The activities and procedures required to obtain quality samples are arranged in the order in which they are performed. The equipment and methods will vary depending on the type of wells, depth, and laboratory testing program.

Prior to sample collection, each well will be inspected and conditions potentially affecting the integrity of the well and validity of analytical results of samples collected from the well will be recorded on a Well Inspection Report form (Appendix E). Laboratory-quality polyvinyl chloride (PVC) or latex gloves will be worn throughout the sampling process and changed between each well.

The following equipment and supplies may be used during the collection of groundwater samples from Site monitoring wells:

- Electronic water level indicator capable of monitoring to 0.01 foot accuracy
- Extra batteries for water level indicator
- Submersible pump with low-flow capabilities (less than 1 liter/min), such as a bladder pump (with sufficient quantity of bladders, O-rings, grab plates, etc.)
- Peristaltic pump
- Source of power for use with submersible or peristaltic pump (e.g., 12-volt battery, compressor, generator, compressed gas tanks, etc.)
- Flow controller for use with submersible pump (varies depending on the type of pump used)
- Bottom-filling bailer constructed of polyethylene, polyvinyl chloride (PVC), stainless steel or Teflon®
- Bailer cord or wire (recommended Teflon®-coated, stainless steel cable; bailer wire; or contaminant-free rope with a Teflon®-coated stainless steel leader to connect bailer and rope)
- Tubing (Teflon® or polyethylene)
- Silicone tubing (only used for peristaltic pump head and/or flow-through cell connections)
- Water quality meter(s) capable of measuring field parameters such as pH, temperature, specific conductivity, oxidation-reduction potential, and dissolved oxygen
- Flow-through cell
- Turbidity meter
- Well lock keys
- Containers with lids for purge water (*e.g.*, 5-gallon buckets, drums, etc.)

- Stopwatch or timer
- Graduated measuring container appropriately sized to measure flow rate
- Sample bottle labels
- Laboratory-grade water (for equipment blanks if needed)
- Chain of custody forms
- Sample cooler(s)
- Sample containers
- Field book and/or Groundwater Field Data Record
- Bubble wrap and Ziploc® bags
- Lint-free, non-abrasive, disposable towels (e.g., Kimwipes®)
- Indelible marking pens
- Ice

5.1 Monitoring Well Inspection

During groundwater sampling activities, monitoring wells will be inspected to ensure that they are secure (locked) and not damaged. A written or electronic well inspection form (Appendix E) will be completed during each sampling event for each well. The well inspection form will document the condition of the well protective casing, lock, cap, well pad, interior well casing, and surrounding areas of the groundwater monitoring well, etc. Deficiencies observed, along with documentation of any modifications or repairs completed, will be noted on the well inspection form.

In the event that a well component becomes damaged, the component will be noted on the inspection sheet and evaluated for repair or replacement. In the event that a monitoring well becomes damaged and cannot be sampled, VDEQ will be notified of the damaged well within 30 days of recognizing non-performance and proposed corrective measures will be provided to the VDEQ. Appropriate corrective measures will be implemented or a replacement monitoring well installed in the vicinity of the damaged well. Prior to replacement of any non-performance monitoring well, the VDEQ will be provided with the proposed replacement well location to include the proposed location depicted on a site plan for review consistent with 9 VAC 20-81-530.C.1. Effort will be made to install the replacement well on a schedule that will make it available for monitoring during the next scheduled sampling event.

5.2 Field Notes

Personnel who collect samples are responsible for recording pertinent information in field books or logsheets. A blank log sheet for groundwater monitoring is included as Appendix F. This information includes data on the depth to water, total depth of well, turbidity, time of sampling, pH, conductivity, temperature, and other pertinent data. These notes are a valuable record of the conditions in the field and problems that might be encountered and are used in the data interpretation and analysis of the laboratory results.

The pages in the field books or logsheets will be dated and signed or initialed by the person who is recording the information. Work sketches or phrases that are recorded, but deemed incorrect, will be marked through in such a way as to still be legible, yet obviously struck from the text. Mark-throughs will be initialed and dated by the person striking the item.

5.3 Water Level and Well Depth Measurements

Water level (*i.e.,* depth to water) measurements are used to determine the water table elevation or potentiometric head in monitoring wells and the water table configuration at the site. The depth of well measurement is used to calculate the volume of standing water in the well. These measurements will be performed before any water is removed from a well.

Groundwater level measurements are made relative to an established reference point on the well casing. Reference points at the site are tied in with the North American Vertical Datum (NAVD88). Groundwater level measurements will be made and recorded to the nearest 0.01 foot. The calculated elevations will be reported to the nearest 0.01 foot.

An electric water level indicator will be used for water level measurements, if available. As a contingency method for determining the depth to water (*i.e.,* if electric water level indicator malfunctions or is unavailable), a steel tape with chalk may be used. Both devices are calibrated to 0.01 ft.

Groundwater level measurement procedures consist of the following:

1. Unlock the well and inspect well for evidence of disturbance.
2. Turn the water level indicator to the "ON" position and press the test button. The light should come on and the buzzer should sound. Replace the battery, if necessary.
3. Place probe inside of well and unreel the cable slowly down the well and listen for the buzzer to indicate the probe is in the water.
4. Pull the cable up approximately two inches.

5. Slowly lower the cable down the well until you hear the buzzer sound. Mark the point on the cable with a clip or finger.
6. Read the depth on the water level indicator and record the depth to water in the field book or logsheet.

The water level indicator will be decontaminated prior to its first use and between wells by rinsing with deionized, organic-free water.

5.4 Sampling Order

The compliance wells are equipped with dedicated purging and sampling equipment; therefore, the likelihood of cross-contamination at this Site is minimized. Accordingly, the anticipated sampling order will follow a sequence based on consideration of field conditions at the time of sampling.

5.5 Well Purging

Each well will be purged before a sample is collected. Purging a well is important because water that has remained in a well casing for a period of time may not be representative of the water contained in the surrounding formation that the well is intended to sample. Groundwater purging will be conducted utilizing USEPA protocol for low stress (low-flow) purging and sampling (EQASOP-GW 001, 1996, revised 2010). Utilizing this method, the pump intake is placed within the screened interval of the well, and the well is pumped slowly, keeping the drawdown to a minimum until the water quality parameters (*i.e.*, pH, specific conductance and temperature) have stabilized. This purging method reduces turbidity and the potential for suspended sediment in the sample.

The wells are currently equipped with in-place bladder pumps. In the event that the in-place pump is not operational or has been removed, the wells may also be purged using an adjustable rate peristaltic pump, a variable speed electric submersible pump, or inertial pump constructed of stainless steel or Teflon®. Purging and sampling with a bailer should be avoided. Purge water will then be discharged to the basins.

The color, odor, turbidity, and any other comments pertaining to the purge water will be documented in the field log. Water quality parameters will be measured and recorded in the field log. Adequate purging is achieved when the pH and specific conductance of the groundwater have stabilized and the turbidity has either stabilized or is below 10 nephelometric turbidity units (ntu). However, when sampling for metals, purging may need to be extended in order to achieve a turbidity value of 10 ntu or less prior to sampling.

Purging procedures for monitoring wells include the following:

1. Measure depth to water.
2. If a pump is not already installed in the well, lower the pump (or tubing) down the well. Position the pump intake within the screened interval of the well. If possible, keep the pump at least 2 ft above the bottom of the well.
3. Begin purging at the lowest pressure/power flow rate setting (*e.g.*, 100 mL/min), then slowly increase until water begins discharging. Monitor the water level in well. Adjust pump speed until there is little or no water level drawdown.
4. Measure and record the flow rate and water level every 3 to 5 minutes during purging. The flow rate should be reduced if drawdown is greater than 0.3 ft over three consecutive 3 to 5 minute interval readings.
5. Measure and record pH, temperature, specific electrical conductance (SEC), and turbidity every 3 to 5 minutes during purging. Purging or stabilization will be considered complete when water quality parameters have stabilized, which is determined when three consecutive readings agree within 0.1 units for pH, 3 percent for SEC, and 10 percent for turbidity or a value of less than 10 ntu is reached. If three turbidity readings are within 10% of one another, the values are considered as stabilized. These measurements, in addition to a physical description of the sample, sampling time, and disposition of sample, will be recorded in a logbook or on log sheets.

5.6 Well Sampling

Groundwater samples will be collected upon stabilization of field parameters. The same flow rate used during well purging will be used for sample collection. Prior to sampling, disconnect the pump tubing from the flow-through cell. Samples must be collected directly from the discharge port of the pump tubing prior to passing through the flow-through cell (if one is used).

For the wells that are purged dry prior to stabilization, samples can be collected if the well recovers within 8 hours of purging it dry. Should a well not recover within 8 hours, the well may be declared dry and no sample will be collected during the event. However, up to 24 hours can be used to collect a sample following purging.

Section 259.93(i) of the CCR Rule and 9VAC20-81-250(A)(4)(b) specify that metals will be analyzed for “total recoverable metals.” Therefore, the samples will not be field-filtered prior to analysis. Measurement of total recoverable metals will capture both the particulate fraction and dissolved fraction of metals in groundwater at the basins. Sample containers for the total recoverable metals analyses will be filled directly from the sampling device.

Anticipated sample container, minimum volume, chemical preservative, and holding times for each analysis type are provided in Table 4-2, and may change depending on laboratory requirements. One sample will be collected from each well listed on Table 3-1 during each monitoring event. In addition, one duplicate sample will be collected from one of the wells listed on Table 3-1 during each event.

During sample collection, bottles for specific constituent analyses are generally filled in order of decreasing volatility. Because the parameters listed on Table 4-1 and 4-2 are not volatile, no specific sampling order is required.

5.7 Decontamination Procedures

Proper decontamination of sampling equipment is essential to prevent cross contamination of samples with the sampling device. All sampling equipment will be decontaminated before sampling and between each sample. The following decontamination procedure will be sufficient to meet project needs.

1. Clean with tap water and laboratory detergent using a brush if necessary to remove particulate matter and surface films.
2. Rinse thoroughly with tap water.
3. Rinse thoroughly with deionized water.
4. Rinse thoroughly with organic-free water and allow to air dry.
5. Protect cleaned equipment from contamination during storage or transportation.

5.8 Waste Management Practices

Groundwater and other waste produced during the site monitoring and sampling activities will be managed as described in Subsection 3.2.6. Groundwater samples analyzed by the laboratory will be disposed of by the laboratory in accordance with their standard operating procedures (SOPs).

5.9 Sample Preservation and Shipment

Sample containers, preservation methods, and holding times that meet USEPA standards will be used and are summarized for each analytical constituent in Table 4-2. To prevent contamination, new and/or laboratory cleaned and supplied containers will be used for all samples. For samples that require preservation, preservatives will be placed in the containers by the analytical laboratory before sample collection. Aqueous samples requiring preservation will be checked immediately upon arrival at the laboratory for adequate pH adjustment. Additional preservative will be added by the laboratory, if required.

Samples will be collected in the appropriate container, and the sample container will be filled completely to minimize head space. Care must be taken not to overrun the bottles containing preservatives. All sample containers will be placed on ice immediately after collection. Sample containers will be shipped to the off-site laboratory using an overnight delivery service or by hand delivery.

Field conditions such as vehicle or generator exhaust or the presence of dusty conditions must be noted, and the appropriate field QC blanks collected or sampling suspended until conditions improve.

Glass bottles will be placed in bubble wrap to help prevent breakage.

For delivery of all samples to the laboratory, the following will be done:

1. Collect and preserve the samples as outlined in this GWMP. Properly label each container with indelible, waterproof ink.
2. Place sample containers in laboratory shipping container(s). Samples will be packed securely with packing material (*e.g.*, bubble wrap) to protect sample containers from accidental breakage during shipment.
3. Chill samples with ice or frozen chemical ice packs placed around the containers.
4. Complete the chain-of-custody forms.
5. Tape chain-of-custody form to the inside of the shipping container lid.
6. Seal shipping container with tape. Place custody seal on container if it is being shipped by common carrier.
7. Deliver or ship to the off-site laboratory. Fastest available shipping methods will be used whenever required by short holding times or project schedules.

Responsibility for proper use of containers and preservatives is the duty of the sampling personnel and the project laboratory coordinator. For specific container types, volumes, and preservatives for analytical parameters of this monitoring program refer to Table 4-2. An example copy of a sample label and a sample seal are provided in Appendix G.

5.10 Chain-of-Custody Control

Sample possession must be traceable from the time of collection to ultimate disposal through the use of chain-of-custody procedures. Chain-of-custody forms must accompany all sample shipping containers in order to document the transfer of the shipping containers and samples from the field to the laboratory. Procedures to be implemented include the following:

- Prepare sample containers in the laboratory with pre-applied labels.

- Complete chain-of-custody form(s) in the field indicating sample identification, size and number of containers filled, sampling date, sampling time, sample collector, and sample preservative, if applicable. Note that sampling time and date are left blank for blind duplicate samples. The sampling location of blind duplicates is recorded in the field notes.
- Pack shipping containers with samples, field chain-of-custody forms, and ice or ice packs. Each set of sample containers to be shipped together in a single shipping container will be assigned a field chain-of-custody form, which will travel with the shipping container.
- Seal containers and ship them to a Virginia Environmental Laboratory Accreditation Program (VELAP) certified laboratory. Common carriers or intermediate individuals shall be identified on the field chain-of-custody form, and copies of all bills-of-lading will be retained.
- In the laboratory, receive and check shipping containers for broken seals or damaged sample containers. If no problems are noted, samples will be logged into the laboratory, and the field chain-of-custody form will be completed. The person relinquishing the samples to the facility or agency should request the representative's signature acknowledging sample receipt. If the representative is unavailable or refuses, this is noted in the "Received By" space.
- Include copies of the field chain-of-custody form with the analytical data.

The chain-of-custody form will be filled out legibly in black or blue ink. Errors will be corrected by drawing a single line through the incorrect information and entering the correct information. All corrections will be initialed and dated by the person making the correction.

Completed chain-of-custody forms will be placed in a plastic bag, sealed, and taped to the inside cover of the shipping container. After the samples are iced, if required, the shipping container will be sealed, dated, and delivered by the sampling technician or shipped to the laboratory using an overnight delivery service. Samples will be received from the carrier and logged by the laboratory staff. In the event that samples are shipped for Saturday delivery, or delivered to the laboratory directly by the sampling technician after hours, arrangements will be made to have the appropriate personnel present to receive and log the samples upon their arrival or the samples will be stored in a secured location until the next business day. Sample shipping containers will not be left unattended.

A separate sample receipt will be prepared whenever samples are split with a government agency or other entity. The receipt will be marked to indicate with whom the samples are being split. The person relinquishing the samples to the agency should request the agency representative's signature acknowledging sample receipt. If the representative is unavailable or refuses, this will be noted on the receipt and in the field book.

Three copies of the chain-of-custody will be available with the field notes in the field. Two of the copies will accompany the samples to the laboratory. If a chain-of-custody form is damaged in shipment, the third (field copy) will be available. A written statement will be prepared by the person who collected the samples. The statement should include information contained in the field book/log entries regarding the sample. An example copy of a chain-of-custody form is included in Appendix G.

5.11 Quality Assurance and Quality Control

Groundwater sampling procedures are designed to provide a representative sample of groundwater for chemical analysis. Specific procedures for collecting groundwater samples to monitor water quality are outlined below and are based on established and accepted procedures. These methods have been developed over several years, and USEPA-approved procedures, such as USEPA Region 4 *Field Branches Quality System and Technical Procedures*, are used wherever applicable. Proper sampling techniques are necessary to provide representative samples that have not been altered or contaminated by the sampling procedure.

Several steps are taken in the field to assure sample QC. Some of these steps include the following:

- Decontaminating the water level tape and probe prior to using and between wells.
- Assure cleaned equipment does not come into contact with soil around the well.
- Preparing a field blank sample consisting of organic-free water, which has been subjected to the same field methods as the samples.
- Field calibration of meters used for pH, turbidity, and conductivity.
- Sampling and analysis of a minimum of one duplicate sample per groundwater monitoring event.

Field QC samples are collected to assess the quality of the analytical data and to evaluate sampling and analytical reproducibility (precision). Field QC samples will consist of duplicate samples and field blanks for QA/QC. Type 1 reagent grade water will be used as the water source for all field blank samples.

Duplicate Samples

Duplicate samples, prepared by splitting a single sample between two separate containers, are used to evaluate sampling and analytical reproducibility (precision). A field duplicate will be collected for each full monitoring event. Points where duplicate samples are to be collected will be selected at random in the field. The samples will be submitted as blind duplicates to the laboratory.

Field Blanks

A field blank is a set of sample bottles that are filled with organic-free deionized water in the field. The deionized water is handled in the same manner as the sample. Field blanks contain the same preservatives as the samples.

5.12 Field Parameter Measurements

The pH, conductivity, temperature, and turbidity of all water samples are taken in the field. The measurements are performed on an unfiltered sample. The meters are calibrated in the laboratory prior to departure and checked in the field in accordance with the equipment manufacturer or laboratory specifications.

5.13 Data Validation

The laboratory is responsible for verifying that reported analytical results are correct. Laboratory data validation will be performed by an independent data validation specialist. Data will be evaluated based on validation criteria set forth in the National Functional Guidelines for Superfund Organic Methods Data Review, document number USEPA-540-R-014-002, August 2014, and National Functional Guidelines for Inorganic Superfund Data Review, document number USEPA-540-R-013-001, August 2014, or previous versions of the National Functional Guidelines, as appropriate, as they apply to the reported methodology.

Section 6
Groundwater Data Evaluation

Statistical evaluation of the data will be conducted as discussed in the following subsections. These procedures represent a conservative approach to groundwater evaluation and incorporate appropriate statistical and other evaluation methodologies consistent with *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities*, Unified Guidance March 2009 (EPA 530/R-09-007). It is assumed that the statistical evaluations will be conducted using an appropriate statistical software package such as USEPA's ProUCL or similar.

Because the basins subject to this groundwater monitoring program have been in use for an extended period of time prior to initiating this program, statistical evaluations will consist of inter-well evaluations between the upgradient well (or GPS under assessment monitoring) and individual downgradient monitoring wells.

In accordance with the CCR rule and VSWMR, statistical evaluation of the groundwater data may occur in several phases as follows:

- Establishing background or baseline concentrations
- Comparing downgradient groundwater concentrations to background during the detection monitoring
- Establishing GPS upon triggering assessment monitoring
- Comparing groundwater concentrations to GPS during the assessment monitoring

In accordance with the VSWMR Program, the facility will be permitted under the Modified Assessment Monitoring Program only.

6.1 General Statistical Methodology

The methods that will be used for statistical evaluation are based on certain assumptions about the data sets being evaluated. Before conducting the statistical evaluations, the validated data will be tested for substantial conformance with the underlying assumptions of the statistical methods. Appropriate alternative evaluation methods will be used for data sets that do not meet the criteria for the preferred statistical evaluation methods.

Common issues with data sets being subjected to statistical evaluation include the following:

- Concentrations less than the detection limit - 40 CFR 257.93(g)(5) requires that the statistical method account for data less than the limit of detection, which is defined as the limit of quantitation (LOQ). There are a variety of ways to deal with data sets that include values less than detection. General guidelines that will be used to handle the data when less than 100 percent of the data are detections include the following:

- For laboratory data that are reported as estimated values less than the practical quantitation limit, the estimated value will be used.
- When fewer than 25 percent of the data in a data set are less than detection limits and do not have estimated values from the analytical laboratory, simple substitution may be used to provide surrogate values for the nondetect data. Simple substitution values may include the quantitation limit, one-half the quantitation limit, or the method detection limit.
- When fewer than 50 percent of the data in a data set are less than detection limits and do not have estimated values from the analytical laboratory, estimation methods such as the Kaplan-Meier (KM) method or the regression on order statistics (ROS) method may be employed.
- When 50 percent or more of the data in a data set are less than detection limits and do not have estimated values from the analytical laboratory, nonparametric methods will be used.

- Missing data – Data may be missing from a new data set for a variety of reasons including insufficient groundwater present during a sampling event or loss of a sample after collection during shipping or handling at the analytical laboratory. Missing data values may result in an incomplete measure of environmental variability and an increased likelihood of falsely detecting contamination. If data are missing, there is also a danger that the full extent of contamination may not be characterized. Therefore, resampling may occur within 30 days to replace the missing data unless an alternative schedule is otherwise approved by VDEQ.
- Outliers - An outlier is a value that is much different from most other values in a data set for a given groundwater chemical constituent. Reasons for outliers may include the following:
  - Sampling errors or field contamination;
  - Analytical errors or laboratory contamination;
  - Recording or transcription errors;
  - Faulty sample preparation or preservation, or shelf-life exceedance; or
  - Extreme, but accurately detected environmental conditions (e.g., spills, migration from the facility).

  Formal testing for outliers will be conducted only if a value is particularly high compared to the rest of the data set. If a sample value is suspect, formal testing will be conducted using an appropriate outlier test based on the distribution of the other data in the data set as described in Section 12 of *Unified Guidance* (USEPA 2009).

If the test designates an observation as a statistical outlier, the source of the abnormal measurement will be investigated. An outlier will be excluded from use in statistical evaluations if it is determined to have a cause such as contaminated sampling equipment, laboratory contamination of the samples, or errors in transcription of the data values or sample identifications. If no specific reason for an outlier value can be ascertained, the data point may be treated as a true but extreme value and should be excluded from the current data evaluation round. The outlier value should be maintained in the Station's database, and the status of the outlier value should be re-evaluated during future data evaluation rounds.

- Data distribution – 40 CFR 257.93(g)(1) requires that the statistical method be appropriate for the distribution of constituents. Parametric methods will be used for data sets that are normally or lognormally distributed. Non parametric methods will be used for nonnormal data sets. Data sets will be tested for normality using the Shapiro-Wilk Test of Normality for sample size up to 50, and the Shapiro-Francia Test of Normality for sample size more than 50, or other acceptable test methods that have a similar power to detect deviations from the normal distribution. If the original data show that the data are not normally distributed, then the data will be natural log-transformed and retested for normality.
- Seasonal or spatial variation - 40 CFR 257.93(g)(6) requires that any seasonal or spatial variation in the data be controlled or corrected. However, such variation may not be discernible until the background/baseline sampling events have been completed. If seasonal or spatial variation is suspected, detection monitoring will commence on a provisional basis while additional background data are collected to enable appropriate control or correction for seasonal or spatial variation. Seasonal effects are discussed in Section 14 of *Unified Guidance* (USEPA 2009).
- Temporal correlation - 40 CFR 257.93(g)(6) requires that temporal correlation (trends) in the data be controlled or corrected for. If a linear trend in the background data are suspected, an autocorrelation test will be conducted to confirm the suspected trend. The data can be tested and de-trended using methods described in Section 17.3 of *Unified Guidance* (USEPA 2009).

6.2 Establishing Groundwater Protection Standards

The CCR Rule and VSWMR require GPS to be established for Table 4-1 constituents that have been detected. Because the VDEQ requires the facility to be permitted under the Modified Assessment Monitoring Program only, GPS will be established upon completion of the baseline period. GPS values will be established as described in Subsection 4.3 for parameters listed on Table 4-1.

Consistent with VDEQ requirements, MCLs will be the GPS for constituents that have MCLs unless the background concentration exceeds the MCL. For all other parameters, the GPS will be background, but background will be updated every two years consistent with Chapter 5 of *Unified Guidance* (EPA 2009). If additional Modified Assessment Monitoring parameters become detected during the Modified Assessment Monitoring program, GPS will be developed for those parameters in the same manner as the initial Modified Assessment Monitoring parameters.

6.3 Establishing Background and Comparing Compliance Period Data Against Background

As discussed in Subsection 4.2 of this GWMP, baseline groundwater quality data will consist of eight approximately quarterly groundwater samples collected from each well in the monitoring system starting the fourth quarter of 2015. Within 30 days of initially establishing background, re-establishing background due to the installation of new monitoring wells, or a change in sampling technique, background values and the statistical computations forming the basis for these values are to be reported to the VDEQ in a report entitled Facility Background Determination Report. Validation and management of the data are discussed in Subsection 5.13 of this GWMP.

Upon receipt of each new round of baseline samples, the results will be reviewed and placed on time versus concentration graphs. These graphs will be observed for potential outliers or other anomalies, including missing data. If the baseline results have missing data or anomalous data, resampling may be conducted within 30 days of receipt of the data to replace the data. If data are replaced, the original data will either be removed from the database or marked "Do Not Use."

Once the full eight rounds of baseline groundwater monitoring results are available, they will be reviewed for appropriate methods to establish background or baseline concentrations. The common issues with data sets are discussed in Subsection 6.1. Establishing background concentrations is discussed in detail in Section 5 of *Unified Guidance* (EPA 2009).

The initial background/baseline sampling period is eight events. This provides a minimal background data set to initiate statistical comparisons. Over time, the short baseline period may result in a high risk of false positive statistical results. Therefore, the background data set for the upgradient wells will be periodically increased as discussed in Section 5.3 of *Unified Guidance* (USEPA 2009). Background values will be reviewed and updated every two years. The background data will be reviewed for trends or changes that may necessitate discontinuation of earlier portions of the background data set.

The CCR Rule and VSWMR allow a variety of methods for conducting statistical evaluations. The specific procedure for a given data set depends on several factors including the proportion of the data set with detected values and the distribution of the data. These will not be known until the data are collected. It is generally anticipated, however, that the upper tolerance limit or prediction interval method will be the preferred method of establishing background concentrations for groundwater protection standards to the extent that background data support the use of that method. This statistical procedure is described in detail in Chapters 17, 18 and 19 of *Unified Guidance* (USEPA 2009).

As each new set of groundwater monitoring results is obtained, the data will be observed for missing and outlier data. Missing data and outlier data that appear to be caused by an error (sampling, analysis, transcription, etc.) will be replaced by resampling within 30 days.

If the direct comparisons to the background and/or GPS conclude that an SSI may have occurred, verification resampling will be conducted for that constituent in that well within 30-days of the laboratory report issuance. Once the resampling data are available, the statistical test will be repeated with the resampling result replacing the initial result. If the test again concludes an SSI has occurred, VDEQ will be notified within the specified timeframes.

6.4 Modified Assessment Monitoring Program

The Modified Assessment Monitoring Program requires statistical comparisons of subsequent groundwater monitoring results to background and/or GPS established as described in Subsections 4.3 and 6.3. Thus, the statistical evaluations for constituents with MCLs will consist of comparisons to a single value. Consistent with *Unified Guidance* (USEPA 2009), the preferred method for statistical comparisons to a fixed standard will be confidence limits. An exceedance of the standard occurs when the 95 percent lower confidence limit (LCL) of the downgradient data exceeds the GPS. Confidence intervals will be established in a manner appropriate to the data set being evaluated (proportion of nondetect data, distribution, etc.). The data set for each compliance period will be the data collected during that monitoring period. If a potential SSI is indicated, three additional independent groundwater samples may be collected within the timeframe of the compliance period for statistical evaluation (total of 4 values for the statistical comparison). Confidence intervals are discussed in Sections 21 and 22 of *Unified Guidance* (USEPA 2009). During each semiannual assessment monitoring event, initial comparisons will be made by direct comparison of the result to the GPS; statistical evaluation will be conducted only if a result exceeds the GPS (MCL).

For detected constituents that do not have an MCL, or for which the background concentration exceeds the MCL, the GPS will be calculated by parametric tolerance or prediction limits as follows. For all interval methods, the normality or log-normality of the background data set (updated every two years) and the percentage of non-detects in the background dataset will be checked. If the background data set is normally or log-normally distributed and there are less than 50 percent nondetects, then a parametric interval will be calculated. If a distribution cannot be established for the background dataset or 50 percent or more of the data are nondetects, the facility will calculate a nonparametric statistical limit. Prediction interval or tolerance limit parameter values will include an alpha value no less than 0.01 and the coverage for tolerance intervals will not be greater than 95% unless the facility demonstrates that a lower false positive rate (or higher coverage for tolerance intervals) will provide at least 50 percent power to detect a 3-standard deviation increase above background levels and 80 percent power to detect a 4-standard deviation increase above background levels for an individual constituent/well comparison.

Section 7
Reporting and Recordkeeping

Both the CCR Rule and the VSWMR include specific reporting and recordkeeping requirements. This section describes the requirements of both programs. The timing of semiannual sampling events will be planned, to the extent possible, such that the two different reporting schedules will coincide.

7.1 VSWMR Reporting

VSWMR reporting to the VDEQ is required within 120 days of receipt of laboratory data from each monitoring event. An annual report is also required within 120 days of receipt of laboratory data from the last semiannual sampling event or no later than January 31 of the following calendar year in lieu of the single event report.

The semiannual reports are required to be prepared and submitted in accordance with VDEQ guidance and forms. Semiannual reports include the following information for that monitoring event:

- Semiannual Groundwater Report Form
- Location Map (USGS 7½ minute Topographic Map)
- Groundwater elevation table (as measured during the sampling event)
- Groundwater flow rate calculations
- Potentiometric surface map (scaled to fit no larger than 11 inch x 17 inch sheet
- Table of constituents exceeding background
- Table of constituents exceeding the groundwater protection standard
- Laboratory Analytical Report
- Chain-of-Custody documentation
- Field book documentation
- Statistical data sheets
- Special conditions description (if applicable)
- Certification

The annual reports are required to include the following information for the preceding year of monitoring:

- Signature page
- Completed QA/QC VDEQ Form ARSC-01
- CCR unit name, type, and permit number
- Summary of design type, operational history, and size of the landfill
- Description of surrounding land use including private wells used for potable water
- Discussion of the topographic, geologic, and hydrologic setting of the landfill, including the uppermost aquifer and proximity to surface waters
- Discussion of the monitoring well network
- Listing of the groundwater sampling events for the reporting period
- Historical table of detected constituents and their concentrations in each well during the sampling period
- Evaluations and responses to groundwater elevation data, groundwater flow rate, groundwater flow direction

7.2 CCR Reporting

The CCR Rule requires collection of eight baseline groundwater monitoring events by October 17, 2017, followed by statistical evaluation and preparation of a first annual groundwater monitoring report by January 31, 2018. Subsequent groundwater monitoring reports are to be submitted as follows:

- Annual Groundwater Monitoring Reports

  The Annual Groundwater Monitoring Report is due no later than 120 days from the completion of sampling and analysis conducted for the second semi-annual event or no later than January 31 of the following calendar year.

Each annual report will provide the following in accordance with 40 CFR 257.90(e):

- Status of the GWMP, which will vary depending on the level of monitoring being performed (background, detection, assessment, or corrective action)
- Map showing the CCR units and monitoring points
- Identification of wells installed or decommissioned during the year being reported
- Monitoring data for the year being reported (in the case of the first report, eight background events over two years will be reported)

- Discussion of statistical evaluations, as applicable
- Narrative of any transition between monitoring programs (*e.g.*, background, detection, assessment, or corrective action), as applicable

7.3 Record Keeping

Record keeping under the VSWMR includes establishing an Operating Record for placement of specified records including:

- Groundwater protection standards
- MCL and background revisions

In accordance with 9VAC20-81-250 E, records pertaining to groundwater monitoring activities will be retained at a specified location by the owner/operator throughout the active life and post-closure care period of the unit being monitored. Retained records will include:

- Groundwater surface elevation data
- Laboratory analytical results
- Records of well installation, repair, or abandonment
- Correspondence with VDEQ
- Approved variances

In accordance with the CCR Rule, Dominion shall comply with the applicable recordkeeping, notification, and reporting requirements as specified in 40 CFR 257.105-107. These reports will be posted on Dominion's publicly accessible Web site and the laboratory results will be maintained by Dominion in its laboratory information management system (LIMS) and in on-site operating records.

Section 8
References

Black & Veatch, undated – estimated 1990, Old Dominion Electric cooperative Virginia Power Groundwater Monitoring System for Wastewater Ponds, Clover Project, Halifax County, Virginia.

Federal Register, Vol. 80 No. 74, April 17, 2015, 40 CFR Parts 257 and 261, Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule

Fetter, C.W. 1988. Applied Hydrogeology, Merrill Publishing Company, Second Edition.

LeGrand, Harry, E. 1960. Geology and Ground-Water Resources of Pittsylvania and Halifax Counties, Virginia Division of Mineral Resources, Bulletin 75.

USEPA Region 1. 1996. Low Stress (low flow) Purging and Sampling Procedure from the Collection of Groundwater Samples from Monitoring Wells, EQASOP-GW 001. July 30, 1996. Revised January 19, 2010.

USEPA. 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities*, Unified Guidance, March 2009 (EPA 530/R-09-007).

Virginia Administrative Code, Title 9. Environment, Agency 20. Virginia Waste Management Board, Chapter 81. Solid Waste Management Regulations, Section 250. Groundwater monitoring program. Derived from Volume 27, Issue 12, eff. March 16, 2011; amended, Virginia Register Volume 27, Issue 22, eff. August 3, 2011.

Virginia Department of Mines, Minerals and Energy website. https://www.dmme.virginia.gov/webmaps/DGMR/

Appendix A
Selected Boring Logs from Black & Veatch Report

CLIENT		PROJECT	PROJECT NO.
Old Dominion Electric Cooperative		ODEC Unit 1	15348
PROJECT LOCATION: Clover, Virginia	COORDINATES: N196507 E1940487	ELEVATION (DATUM): 360.8 (MSL); TOTAL DEPTH: 49.8'	DATE START: 1/20/89
SURFACE CONDITIONS: Meadow, very grassy		INSPECTOR: J. Kottemann/S. Brand	DATE FINISH: 1/21/89
	CHECKED BY: J. D. Grob	APPROVED BY: L. J. Almaleh	

SAMP TYPE	SAMP NO.	1ST 6"	2ND 6"	3RD 6"	N VAL	SAMP RECV	DEPTH IN FEET	CLASSIFICATION OF MATERIAL	REMARKS
							0–3		6" diameter hollow stem auger
SPT	1	3	5	5	10	1.0	3–4.5	Silty CLAY; reddish-brown; stiff; medium plasticity; very moist; iron oxide staining; trace fine sand	California sampler driven with 140 lb hammer dropped 30"
SPT	2	6	7	9	16	1.5	5–6.5	Grading to very stiff; gray	
CAL	3	9	12	18		2.0	8–10	Grading with more iron staining	
SPT	4	6	12	15	27	1.5	10–11.5	Grading to reddish-brown with gray mottling; trace sand	Pressuremeter test at 13'
SPT	5	31	37	48	85	1.5	15–16.5	Quartz GRAVEL; white-red; very dense; angular; strongly cemented	
							16.5–21.5	Silty SAND; black-brown; very dense; poorly graded; cemented (residual material)	Advanced boring below with rotary wash using 2-15/16" Tricone at 18'
SPT	6	43	45	50	95	0.5	18–19.5		
SPT	7	43	50/5"			0.4	21.5–27.5	Sandy SILT; brown with pink and black mottling; very dense; moist; some mica; highly structured	Very hard drilling at 24'
SPT	8	50/4"				0.3	27.5–30	Silty SAND; black with white and brown speckles; very dense; poorly graded	

Coring columns (CORE SIZE, RUN NO., RUN LENG, RUN RECV, RQD RECV, % RECV, RQD): no entries.

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CLIENT Old Dominion Electric Cooperative		PROJECT ODEC Unit 1		PROJECT NO. 15348
PROJECT LOCATION Clover, Virginia	COORDINATES N196507 E1940487	ELEVATION (DATUM) 360.8 (MSL)	TOTAL DEPTH 49.8'	DATE START 1/20/89
SURFACE CONDITIONS Meadow, very grassy		INSPECTOR J. Kottemann/S. Brand		DATE FINISH 1/21/89
	CHECKED BY J. D. Grob	APPROVED BY L. J. Almaleh		

SAMPLING: SAMP TYPE / CORING: CORE SIZE	SAMP NO. / RUN NO.	SET 6" / RUN LENG	2ND 6" / RUN RECV	3RD 6" / RQD RECV	N VAL / % RECV	SAMP RECV / RQD	DEPTH IN FEET	SAMPLE TYPE / GRAPHICS LOG	CLASSIFICATION OF MATERIAL	REMARKS
							1		(continued) fine to medium grained; moist; with some mica; some gravel	
SPT	9	50/1"				0.1	4			
							35			
SPT	10	50/1"				0.0	9			Hole advanced with hollow stem augers to provide casing for rock coring.
			39.5							
NX	1	3.3	2.8	0	85	0	40–1		Granite GNEISS; white with pink, gray, and black speckles and streaks; fine to coarsely crystalline; weathered joints spaced 3" or less dipping 41° and 119°; foliation dipping 41° occasional quartz bands; moderately weathered	Began coring at 39.5' after cleaning hole with Tricone bit
			42.8							
NX	2	7.0	2.9	0	41	0	45			
							7–9		Biotite GNEISS; black with white speckles and streaks; finely crystalline; joints spaced 3" or less dipping 42°, 120° foliation dipping 42°; occasional quartz bands; moderately weathered	
			49.8				50			Bottom of boring at 49.8' Water level at 1.5' recorded 48 hours after completion
							55			
							60			

P-ST-036D

BLACK & VEATCH
ENGINEERS-ARCHITECTS

LOG OF BORING

CLIENT: Old Dominion Power Cooperative		PROJECT: ODEC Unit 1	PROJECT NO.: 15348
PROJECT LOCATION: Clover, Virginia	COORDINATES: N195600 E1940240	ELEVATION (DATUM): 381.3 (MSL) / TOTAL DEPTH: 67.5'	DATE START: 1/23/89
SURFACE CONDITIONS: Grassy meadow sloping north		INSPECTOR: J. Kottemann	DATE FINISH: 1/24/89
CHECKED BY: J. D. Grob		APPROVED BY: L. J. Almaleh	

Sampling

SAMP TYPE	SAMP NO.	SET 6"	2ND 6"	3RD 6"	N VAL	SAMP RECV	DEPTH IN FEET (approx.)
SPT	1	4	5	5	10	1.0	3
SPT	2	2	2	4	6	1.2	5
SPT	3	10	18	17	35	1.0	10
SPT	4	18	22	23	45	1.0	17
SPT	5	16	21	24	45	1.1	20.5
SPT	6	50/5"				0.4	24

Coring columns: CORE SIZE, RUN NO., RUN LENG, RUN RECV, RQD RECV, % RECV, RQD (none recorded).

Classification of Material

DEPTH IN FEET	CLASSIFICATION OF MATERIAL	REMARKS
0–7.5	Clayey SILT; reddish-brown with tan and gray mottling; stiff; high plasticity; moist; with some fine sand	Boring advanced using 3-7/8" Tricone roller bit and water for circulation
7	Grading wet	2-15/16" Tricone roller bit used for pressuremeter test intervals
7.5–30	Silty SAND; gray with black and white speckles and streaks; dense; fine to medium grained; moist; highly structured; trace mica (Residual material)	
15		Pressuremeter test at 15.0'
18	Grading less silty; with pink speckles and streaks	

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CLIENT	PROJECT	PROJECT NO.
Old Dominion Power Cooperative	ODEC Unit 1	15348

PROJECT LOCATION	COORDINATES	ELEVATION (DATUM)	TOTAL DEPTH	DATE START
Clover, Virginia	N195600 E1940240	381.3 (MSL)	67.5'	1/23/89

SURFACE CONDITIONS	INSPECTOR	DATE FINISH
Grassy meadow sloping north	J. Kottemann	1/24/89

CHECKED BY	APPROVED BY
J. D. Grob	L. J. Almaleh

SAMPLING: SAMP TYPE / CORING: CORE SIZE	SAMP NO. / RUN NO.	SET 6" / RUN LENG	2ND 6" / RUN RECV	3RD 6" / RQD RECV	N VAL / % RECV	SAMP RECV / RQD	DEPTH IN FEET	SAMPLE TYPE / GRAPHICS LOG	CLASSIFICATION OF MATERIAL	REMARKS
							1			
SPT	7	37	50/4"			0.7	2		Grading with trace coarse sand	
							3			
							4			Pressuremeter test at 35'
							35			
							6			
							7			
SPT	8	28	34	50/5"		0.8	8			
							9			
							40			
SPT	9	50/2"				0.5	1		Grading with trace gravel	
							2			
							3			
							4			
							45			Pressuremeter test at 45'
							6			
SPT	10	50/2"				0.2	7			
							8			
							9			
							50			
							1			
							2			Very hard drilling at 52.5'
							3			
							4			
SPT	11	50/2"				0.2				
							55			
							6			
							7			Rotary wash refusal at 59.5' Installed 60' of 3-1/4" I.D. casing Began coring at 59.5'
							8			
SPT	12	50/0				0.0				
							9			
			59.5							
							60			

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CLIENT	PROJECT	PROJECT NO.
Old Dominion Power Cooperative	ODEC Unit 1	15348

PROJECT LOCATION	COORDINATES	ELEVATION (DATUM)	TOTAL DEPTH	DATE START
Clover, Virginia	N195600 E1940240	381.3 (MSL)	67.5'	1/23/89

SURFACE CONDITIONS	INSPECTOR	DATE FINISH
Grassy meadow sloping north	J. Kottemann	1/24/89

CHECKED BY	APPROVED BY
J. D. Grob	L. J. Almaleh

SAMPLING: SAMP TYPE | SAMP NO. | SET 6" | 2ND 6" | 3RD 6" | N VAL | SAMP RECV

CORING:

CORE SIZE	RUN NO.	RUN LENG	RUN RECV	RQD RECV	% RECV	RQD	DEPTH IN FEET	SAMPLE TYPE / GRAPHICS LOG	CLASSIFICATION OF MATERIAL	REMARKS
NX	1	2.0	2.0	0.7	100	35			Biotite hornblende GNEISS; black with white speckles and streaks; fine to medium crystalline; joints spaced 3" or greater dipping 39°; joint surfaces slightly weathered with some iron oxide staining; foliation dipping 70°; fresh; trace pyrite	
			61.5							
NX	2	6.0	4.5	1.0	75	17	65		Highly fractured quartz zone with mylonite 63.5' to 66.5'	
			67.5							Bottom of boring at 67.5' Water level at 18.0' 48 hours after completion

Depth scale: 1, 2, 3, 4, 65, 6, 7, 8, 9, 70, 1, 2, 3, 4, 75, 6, 7, 8, 9, 80, 1, 2, 3, 4, 85, 6, -, 8, 9, 90

P-ST-0360

BLACK & VEATCH
ENGINEERS-ARCHITECTS

LOG OF BORING

BORING NO. BV-12

CLIENT: Old Dominion Electric Cooperative		PROJECT: ODEC Unit 1		PROJECT NO. 15348
PROJECT LOCATION: Clover, Virginia	COORDINATES: N195400 E1940130	ELEVATION (DATUM): 385.8 (MSL)	TOTAL DEPTH: 65.0'	DATE START: 1/23/89
SURFACE CONDITIONS: Grassy meadow near trees		INSPECTOR: S. Brand		DATE FINISH: 1/25/89
	CHECKED BY: J. D. Grob	APPROVED BY: L. J. Almaleh		

SAMPLING: SAMP TYPE / SAMP NO. / SET 6" / 2ND 6" / 3RD 6" / N VAL / SAMP RECV
CORING: CORE SIZE / RUN NO. / RUN LENG / RUN RECV / RQD RECV / % RECV / RQD

SAMP TYPE	SAMP NO.	SET 6"	2ND 6"	3RD 6"	N VAL	SAMP RECV	DEPTH IN FEET	CLASSIFICATION OF MATERIAL	REMARKS
							1	Sandy SILT; greenish-gray; loose; low plasticity; moist, organics, (topsoil)	6" diameter hollow stem auger with 2-1/4" I.D. x 5' CME continuous sampler
							2	Silty CLAY; reddish-brown with orange; firm; medium plasticity; moist; iron oxide staining; quartz gravel present	
							3		
TW	1					4.5	4		
							5		
							6	Grading soft	
							7		
							8	Quartz GRAVEL; white; dense, coarse grained; (sizes up to 1-1/2" diameter) angular; moist	
TW	2					5.0	9	Silty SAND; green with black-brown streaking; dense; moist; structured (Residual material)	
							10		
							1	Quartz seam; white; at 13.0'	
							2		
							3		Soil structure at 13' dipping 40°
TW	3					4.5	4		Soil structure at 14' horizontal
							15		
							6		No sample for 15' to 20'
							7		
							8		
							9		
							20	Grading very dense; poorly graded; angular; with banded structure	
							1		Hard drilling at 21' to 23'
TW	4					3.0	2		CME refusal at 23.5'. Switched to rotary wash using 2-15/16" Tricone bit and drilled a new hole to 25', switched to a casing advancer at 25'
							3		
							4		
							25		
SPT	5	11	46	50/3"		1.0	6		
							7		
							8		
							9		
SPT	6	50/5"				0.5	30		

P-ST-036D

BLACK & VEATCH
ENGINEERS-ARCHITECTS

LOG OF BORING

CLIENT: Old Dominion Electric Cooperative		PROJECT: ODEC Unit 1		PROJECT NO.: 15348	
PROJECT LOCATION: Clover, Virginia	COORDINATES: N195400 E1940130	ELEVATION (DATUM): 385.8 (MSL)	TOTAL DEPTH: 65.0'	DATE START: 1/23/89	
SURFACE CONDITIONS: Grassy meadow near trees		INSPECTOR: S. Brand		DATE FINISH: 1/25/89	
CHECKED BY: J. D. Grob		APPROVED BY: L. J. Almaleh			

SAMPLING

SAMP TYPE	SAMP NO.	SET 6"	2ND 6"	3RD 6"	N VAL	SAMP RECV
SPT	7	50/5"				0.5
SPT	8	50/4"				0.4
SPT	9	50/3-1/2"				0.3
SPT	10	50/0"				0.0
SPT	11	50/1"				0.0

CORING

CORE SIZE	RUN NO.	RUN LENG	RUN RECV	RQD RECV	% RECV	RQD
			57.0			

DEPTH IN FEET: 1, 2, 3, 4, 35, 6, 7, 8, 9, 40, 1, 2, 3, 4, 45, 6, 7, 8, 9, 50, 1, 2, 3, 4, 55, 6, 7, 8, 9, 60

SAMPLE TYPE / GRAPHICS LOG

CLASSIFICATION OF MATERIAL

Grading to coarser grained; with quartz

Grading; green with pink and white streaking (weathered gneiss)

With some black particles of weathered biolite gneiss and angular quartz

---

QUARTZ; white with black, green streaking; highly foliated; finely crystalline; slightly weathered

REMARKS

Hard drilling at 32' to 33.5'

Hard drilling at 38.0' (losing circulation water)

Very hard drilling at 46.0'

Started coring at 57.0'

P-ST-036D

CLIENT	PROJECT	PROJECT NO.
Old Dominion Electric Cooperative	ODEC Unit 1	15348

PROJECT LOCATION	COORDINATES	ELEVATION (DATUM)	TOTAL DEPTH	DATE START
Clover, Virginia	N195400 E1940130	385.8 (MSL)	65.0'	1/23/89

SURFACE CONDITIONS	INSPECTOR	DATE FINISH
Grassy meadow near trees	S. Brand	1/25/89

CHECKED BY	APPROVED BY
J. D. Grob	L. J. Almaleh

SAMPLING: SAMP TYPE | SAMP NO. | SET 6" | 2ND 6" | 3RD 6" | N VAL | SAMP RECV

CORE SIZE	RUN NO.	RUN LENG	RUN RECV	RQD RECV	% RECV	RQD	DEPTH IN FEET	CLASSIFICATION OF MATERIAL	REMARKS
NX	1	5.0	2.0	0.3	40	6	60–62.0	Biotite GNEISS; black with green and white; highly foliated; finely crystalline; quartz inclusions 1" to 2"; moderately weathered	Highly fractured Horizontal fracture at 62.5'
								QUARTZ vein; white; finely crystalline; moderately weathered	
NX	2	3.3	3.3	1.7	100	52	62.0–65.0	Biotite GNEISS; black with white; green; highly foliated; finely crystalline; some quartz	
							65.0		Bottom of boring at 65.0'
									Water level at 20.0' 24 hours after completion

Depth scale: 1, 2, 3, 4, 65, 6, 7, 8, 9, 70, 1, 2, 3, 4, 75, 6, 7, 8, 9, 80, 1, 2, 3, 4, 85, 6, 7, 8, 9, 90

BLACK & VEATCH
ENGINEERS-ARCHITECTS

LOG OF BORING

BORING NO. BV-13
SHEET 1 of 3

CLIENT	PROJECT	PROJECT NO.
Old Dominion Electric Cooperation	ODEC Unit 1	15348

PROJECT LOCATION	COORDINATES	ELEVATION (DATUM)	TOTAL DEPTH	DATE START
Clover, Virginia	N195258 E1940058	386.7 (MSL)	68.5'	2/1/89

SURFACE CONDITIONS	INSPECTOR	DATE FINISH
Grassy, level, firm	J. D. Grob	2/2/89

CHECKED BY	APPROVED BY
J. D. Grob	L. J. Almaleh

SAMPLING: SAMP TYPE / SAMP NO. / SET 6" / 2ND 6" / 3RD 6" / N VAL / SAMP RECV
CORING: CORE SIZE / RUN NO. / RUN LENG / RUN RECV / RQD RECV / % RECV / RQD

SAMP TYPE	SAMP NO.	SET 6"	2ND 6"	3RD 6"	N VAL	SAMP RECV	DEPTH IN FEET	CLASSIFICATION OF MATERIAL	REMARKS
							0–1	Silty CLAY; reddish-brown; stiff; medium to high plasticity; moist; with trace coarse gravel	Rotary wash with 3-5/8" tricone bit
SPT	1	4	6	10	16	1.5	3		
SPT	2	4	6	9	15	1.5	5.5	with tan mottling	
							7.5	SILT; tan with white mottling; firm; high plasticity; moist to wet; with some structure; fine grained sand (Residual soil)	
SPT	3	6	6	7	13	1.3	9.5		
SPT	4	14	15	16	31	0.3	14.5	Grading with some coarse sand	
							17	Silty SAND; reddish-brown with white and black mottling; very dense; poorly graded; fine to medium grained; with white medium grained quartz sand; moist	
SPT	5	16	20	15	35	0.2	19.5		
							21.5		Pressuremeter test at 21.5'
SPT	6	15	24	26	50	1.3	24.5		
SPT	7	18	38	55	93	1.3	29.5	Grading to green; with some mica	
							30		

P-ST-035D

BLACK & VEATCH
ENGINEERS-ARCHITECTS

LOG OF BORING

BORING NO. BV-13
SHEET 2 of 3

CLIENT	PROJECT	PROJECT NO.
Old Dominion Electric Cooperation	ODEC Unit 1	15348

PROJECT LOCATION	COORDINATES	ELEVATION (DATUM)	TOTAL DEPTH	DATE START
Clover, Virginia	N195258 E1940058	386.7 (MSL)	68.5'	2/1/89

SURFACE CONDITIONS	INSPECTOR	DATE FINISH
Grassy, level, firm	J. D. Grob	2/2/89

CHECKED BY	APPROVED BY
J. D. Grob	L. J. Almaleh

SAMPLING / CORING

SAMP TYPE (CORE SIZE)	SAMP NO. (RUN NO.)	SET 6" (RUN LENG)	2ND 6" (RUN RECV)	3RD 6" (RQD RECV)	N VAL (% RECV)	SAMP RECV (RQD)	DEPTH IN FEET	SAMPLE TYPE / GRAPHICS LOG	CLASSIFICATION OF MATERIAL	REMARKS
							1			
							2			
							3			
SPT	8	34	45	50/6"	95	1.1	4			
							35			
							6			
							7			Pressuremeter test at 36.5'
							8			
SPT	9	28	50/5"			0.6	9		Grading poorly graded; medium grained; sand lenses at 39.0'	
							40			
							1			
							2			Harder drilling at 42.0'
							3			
SPT	10	100/5"				0.2	4		Grading to reddish-brown	
							45			
							6			
							7			
							8			
SPT	11	100/3"				0.3	9		Grading to reddish-brown and green	
							50			
							1			
							2			
SPT	12	100/3"				0.0	3			
							4			
							55			
							6			
							7			
							8			
SPT	13	50/4"				0.2	9		With trace coarse sand	
							60			

CLIENT	PROJECT	PROJECT NO.
Old Dominion Electric Cooperation	ODEC Unit 1	15348

PROJECT LOCATION	COORDINATES	ELEVATION (DATUM)	TOTAL DEPTH	DATE START
Clover, Virginia	N195258 E1940058	386.7 (MSL)	68.5'	2/1/89

SURFACE CONDITIONS	INSPECTOR	DATE FINISH
Grassy, level, firm	J. D. Grob	2/2/89

CHECKED BY	APPROVED BY
J. D. Grob	L. J. Almaleh

SAMPLING: SAMP TYPE | SAMP NO. | SET 6" | 2ND 6" | 3RD 6" | N VAL | SAMP RECV

CORE SIZE	RUN NO.	RUN LENG	RUN RECV	RQD RECV	% RECV	RQD	DEPTH IN FEET	CLASSIFICATION OF MATERIAL	REMARKS
							61–62		Pressuremeter test at 61.5'
			63.5				63	Granite Gneiss; reddish-brown with pink striping and mottling; highly foliated; fine to medium grained; moderately to highly weathered; generally dipping 25° to 30° with fracture perpendicular to dip at 63.6'	Tricone refusal at 63.5' Set up to core at 63.5'
NX	1	5.0	5.0	3.8	100	76	65		
							66–68	Hornblende Gneiss; greenish-black; fine grained; generally dipping 50°; with quartz veins 1/8" to 3/4"; fracture along foliated plane at 67.5'; highly weathered fracture at 67.7'	
			68.5				68.5		Bottom of boring at 68.5'
							70		Water level at 16.0' 24 hours after completion

DEPTH IN FEET scale: 1, 2, 3, 4, 65, 6, 7, 8, 9, 70, 1, 2, 3, 4, 75, 6, 7, 8, 9, 80, 1, 2, 3, 4, 85, 6, 7, 8, 9, 90

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CLIENT	PROJECT	PROJECT NO.
Old Dominion Electric Cooperative	ODEC Unit 1	15348

PROJECT LOCATION	COORDINATES	ELEVATION (DATUM)	TOTAL DEPTH	DATE START
Clover, Virginia	N195050 E1940060	386.1 (MSL)	68.2'	1/26/89

SURFACE CONDITIONS	INSPECTOR	DATE FINISH
Grassy meadow	J. Kottemann/J. D. Grob	1/27/89

CHECKED BY	APPROVED BY
J. D. Grob	L. J. Almaleh

SAMP TYPE	SAMP NO.	1ST 6"	2ND 6"	3RD 6"	N VAL	SAMP RECV	DEPTH IN FEET	CLASSIFICATION OF MATERIAL	REMARKS
							0–15.5	Micaceous sandy SILT: brownish-red with tan mottling; medium dense; wet; trace clay; slightly structured	Boring advanced using 3-7/8" Tricone roller bit and water for circulation
SPT	1	3	5	6	11	1.5	4.5–6		2-15/16" Tricone roller bit used for pressuremeter test intervals
							9	Grading reddish-brown with tan and black streaking and mottling; moist; highly structured	
SPT	2	4	5	8	13	1.4	9.5–11		
SPT	3	5	6	11	17	1.4	14.5–16		
							15.5	Silty SAND; gray with black and white speckling and streaking; medium dense; fine grained; moist; with some mica; trace clay; highly structured	
							20		Pressuremeter test at 20.0'
SPT	4	10	12	20	32	1.0	22–23.5	Grading greenish-tan with black, pink streaking and mottling	
SPT	5	28	26	22	48	1.2	27–28.5	Grading dense	

CORE SIZE	RUN NO.	RUN LENG	RUN RECV	RQD RECV	% RECV	RQD

CLIENT	PROJECT	PROJECT NO.
Old Dominion Electric Cooperative	ODEC Unit 1	15348

PROJECT LOCATION	COORDINATES	ELEVATION (DATUM)	TOTAL DEPTH	DATE START
Clover, Virginia	N195050 E1940060	386.1 (MSL)	68.2'	1/26/89

SURFACE CONDITIONS	INSPECTOR	DATE FINISH
Grassy meadow	J. Kottemann/J. D. Grob	1/27/89

CHECKED BY	APPROVED BY
J. D. Grob	L. J. Almaleh

SAMPLING: SAMP TYPE / CORING: CORE SIZE	SAMP NO. / RUN NO.	SET 6" / RUN LENG	2ND 6" / RUN RECV	3RD 6" / RQD RECV	N VAL / % RECV	SAMP RECV / RQD	DEPTH IN FEET	CLASSIFICATION OF MATERIAL	REMARKS
SPT	6	24	43	50/5"		1.5	32–33	Grading very dense	
							35		Pressuremeter test at 35.0'
SPT	7	23	39	50/4"		1.3	37–38		
SPT	8	16	18	35	53	0.9	42–43		
SPT	9	48	50/5"			0.9	47–48		
SPT	10	50/1"				0.1	52	Grading pink with black and white streaking and mottling	
SPT	11	50/0"				0.0	57		

BLACK & VEATCH
ENGINEERS-ARCHITECTS

LOG OF BORING

BORING NO. BV-27

CLIENT	PROJECT	PROJECT NO.
Old Dominion Electric Cooperative	ODEC Unit 1	15348

PROJECT LOCATION	COORDINATES	ELEVATION (DATUM)	TOTAL DEPTH	DATE START
Clover, Virginia	N195050 E1940060	386.1 (MSL)	68.2'	1/26/89

SURFACE CONDITIONS	INSPECTOR	DATE FINISH
Grassy meadow	J. Kottemann/J. D. Grob	1/27/89

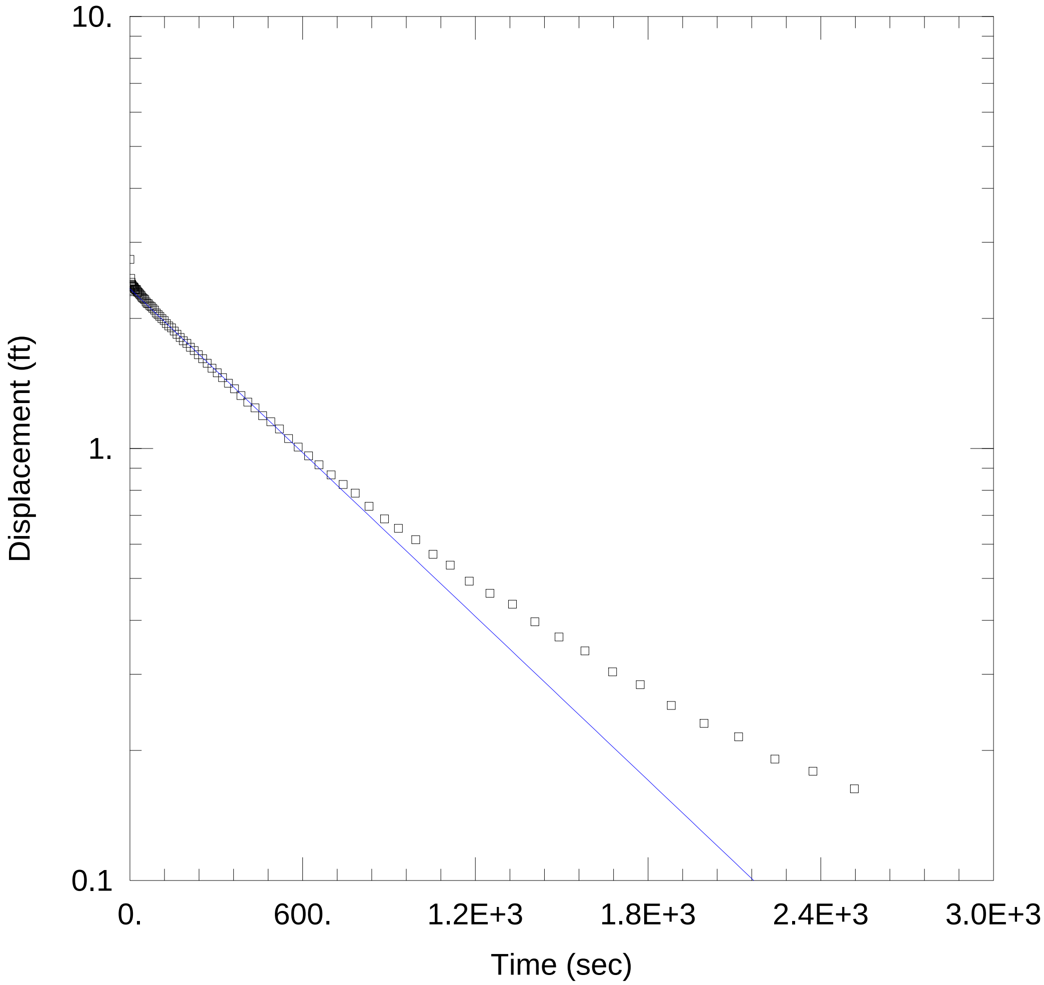
CHECKED BY	APPROVED BY
J. D. Grob	L. J. Almaleh

SAMPLING: SAMP TYPE | SAMP NO. | SET 6" | 2ND 6" | 3RD 6" | N VAL | SAMP RECV

CORE SIZE	RUN NO.	RUN LENG	RUN RECV	RQD RECV	% RECV	RQD	DEPTH IN FEET	SAMPLE TYPE / GRAPHICS LOG	CLASSIFICATION OF MATERIAL	REMARKS
			60.5				60.5			Rotary wash to 60.5'and set casing to core Began coring with NX core barrel at 60.5'
NX	1	4.7	4.2	0.0	89	0.0	60.5–65.2		Granite GNEISS; reddish-brown with pink and white streaking; medium crystalline; highly weathered; foliation generally dipping 30°	
			65.2				65.2			
NX	2	3.0	3.0	0.0	100	0.0	65.2–68.2		Grading more white; finely crystalline; moderately weathered; highly fractured; fractures generally perpendicular to foliation; near vertical healed fracture at 65.2' to 66.2'	
			68.2				68.2			Bottom of boring at 68.2' Water level at completion not recorded Water level at 37.5' 24 hours after completion

P-ST-036D

Appendix B
Aquifer Test Results



FALLING HEAD

Data Set: P:\...\PW-2 Falling Head.aqt
Date: 02/23/16 Time: 16:18:29

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-2
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 33.46 ft Anisotropy Ratio (Kz/Kr): 0.1

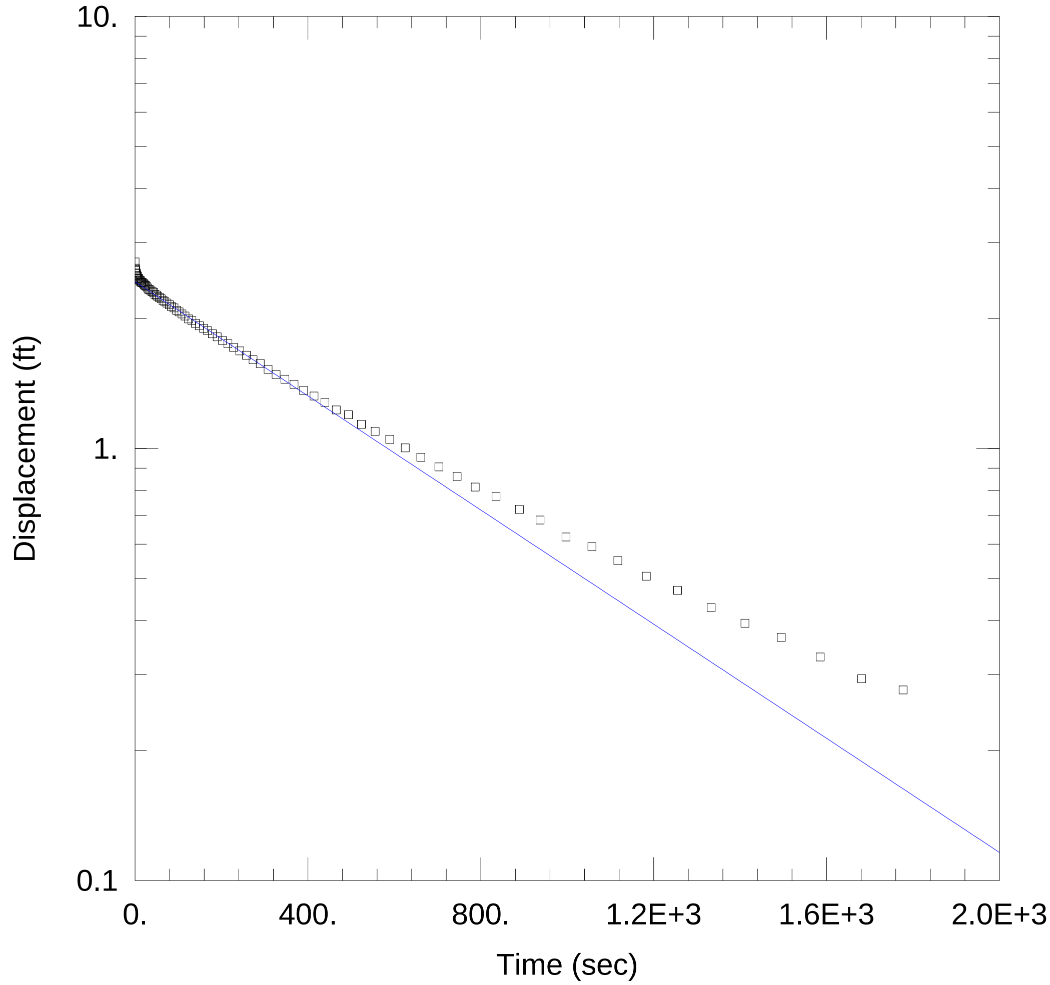
WELL DATA (PW-2)

Initial Displacement: 2.74 ft Static Water Column Height: 24.46 ft
Total Well Penetration Depth: 23.46 ft Screen Length: 15. ft
Casing Radius: 0.166 ft Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.384 ft/day y0 = 2.341 ft



RISING HEAD

Data Set: P:\...\PW-2 Rising Head.aqt
Date: 02/23/16
Time: 16:19:13

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-2
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 33.62 ft
Anisotropy Ratio (Kz/Kr): 0.1

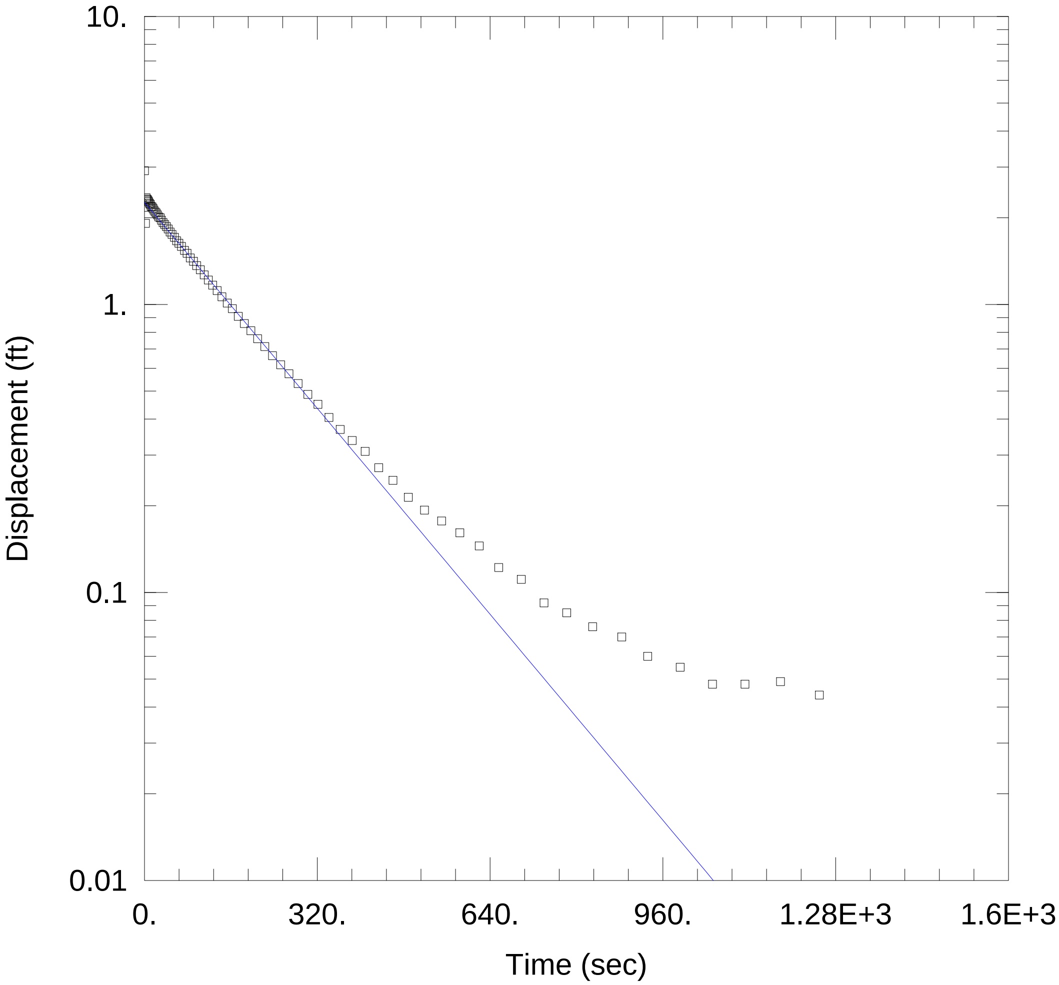
WELL DATA (PW-2)

Initial Displacement: 2.701 ft
Static Water Column Height: 24.62 ft
Total Well Penetration Depth: 23.62 ft
Screen Length: 15. ft
Casing Radius: 0.166 ft
Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.4017 ft/day
y0 = 2.431 ft



FALLING HEAD

Data Set: P:\...\PW-3 Falling Head.aqt
Date: 02/23/16
Time: 16:19:26

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-3
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 30.18 ft
Anisotropy Ratio (Kz/Kr): 0.1

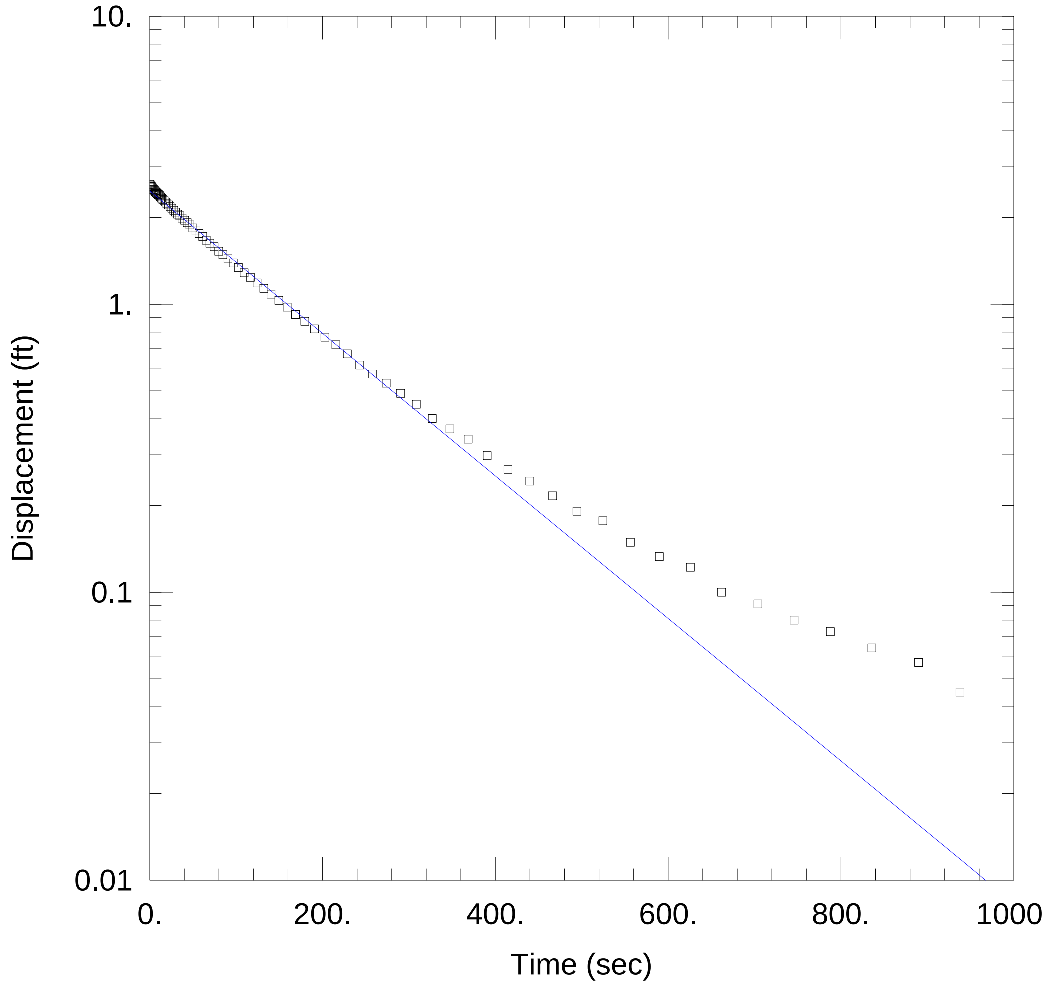
WELL DATA (PW-3)

Initial Displacement: 2.91 ft
Static Water Column Height: 25.18 ft
Total Well Penetration Depth: 24.18 ft
Screen Length: 15. ft
Casing Radius: 0.166 ft
Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 1.38 ft/day
y0 = 2.26 ft



RISING HEAD

Data Set: P:\...\PW-3 Rising Head.aqt
Date: 02/23/16 Time: 16:19:38

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-3
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 30.16 ft Anisotropy Ratio (Kz/Kr): 0.1

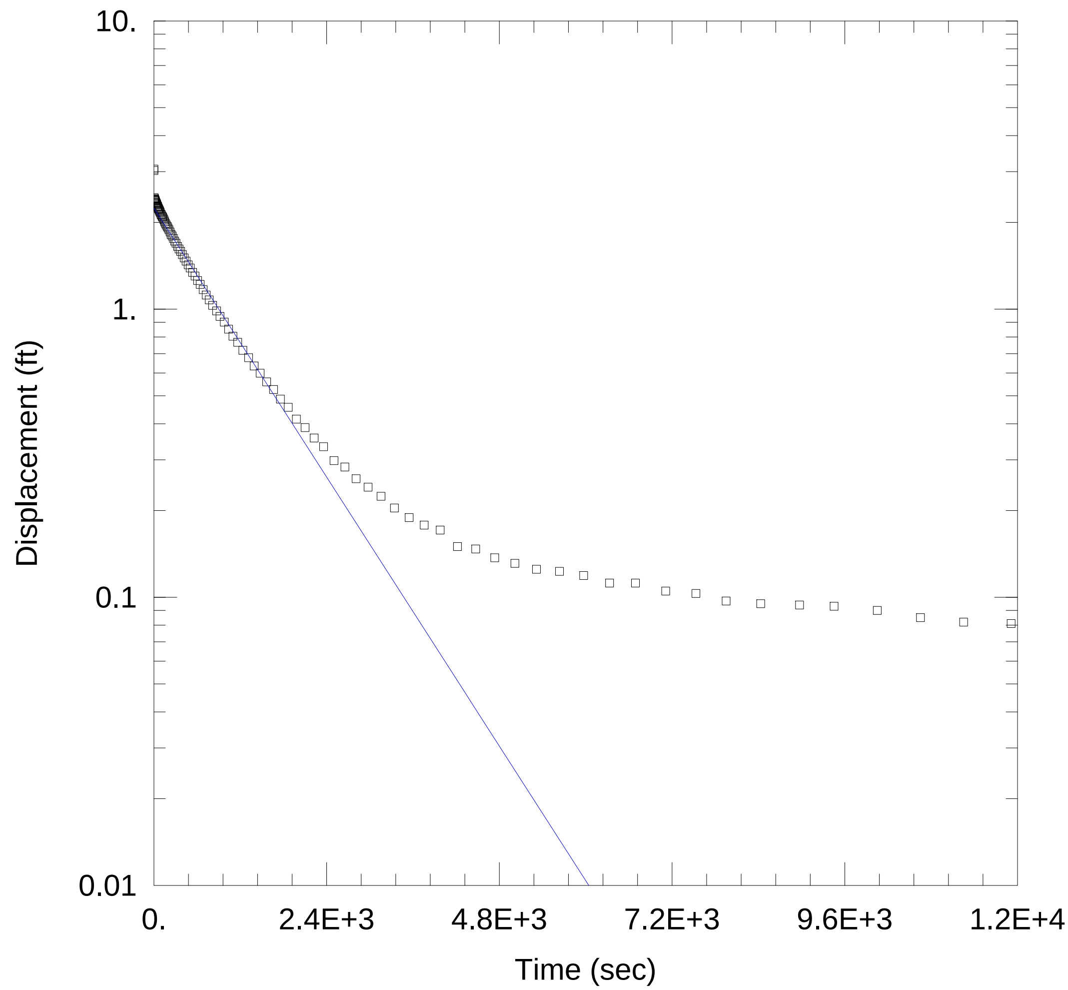
WELL DATA (PW-3)

Initial Displacement: 2.608 ft Static Water Column Height: 25.16 ft
Total Well Penetration Depth: 24.16 ft Screen Length: 15. ft
Casing Radius: 0.166 ft Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 1.528 ft/day y0 = 2.472 ft



FALLING HEAD

Data Set: P:\...\PW-4 Falling Head.aqt
Date: 02/23/16 Time: 16:19:53

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-4
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 25.88 ft Anisotropy Ratio (Kz/Kr): 0.1

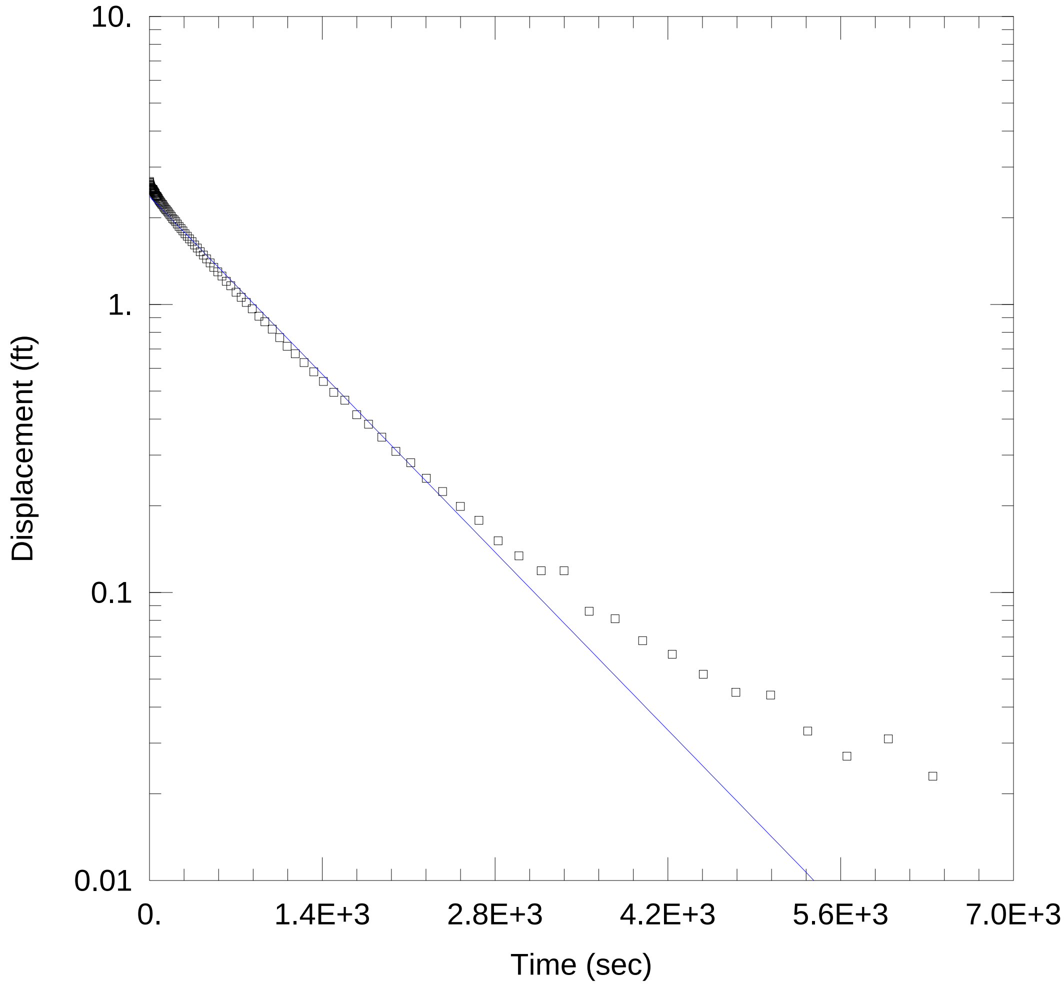
WELL DATA (PW-4)

Initial Displacement: 3.061 ft Static Water Column Height: 26.88 ft
Total Well Penetration Depth: 25.88 ft Screen Length: 15. ft
Casing Radius: 0.166 ft Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.2666 ft/day y0 = 2.24 ft



RISING HEAD

Data Set: P:\...\PW-4 Rising Head.aqt
Date: 02/23/16 Time: 16:20:12

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-4
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 25.85 ft Anisotropy Ratio (Kz/Kr): 0.1

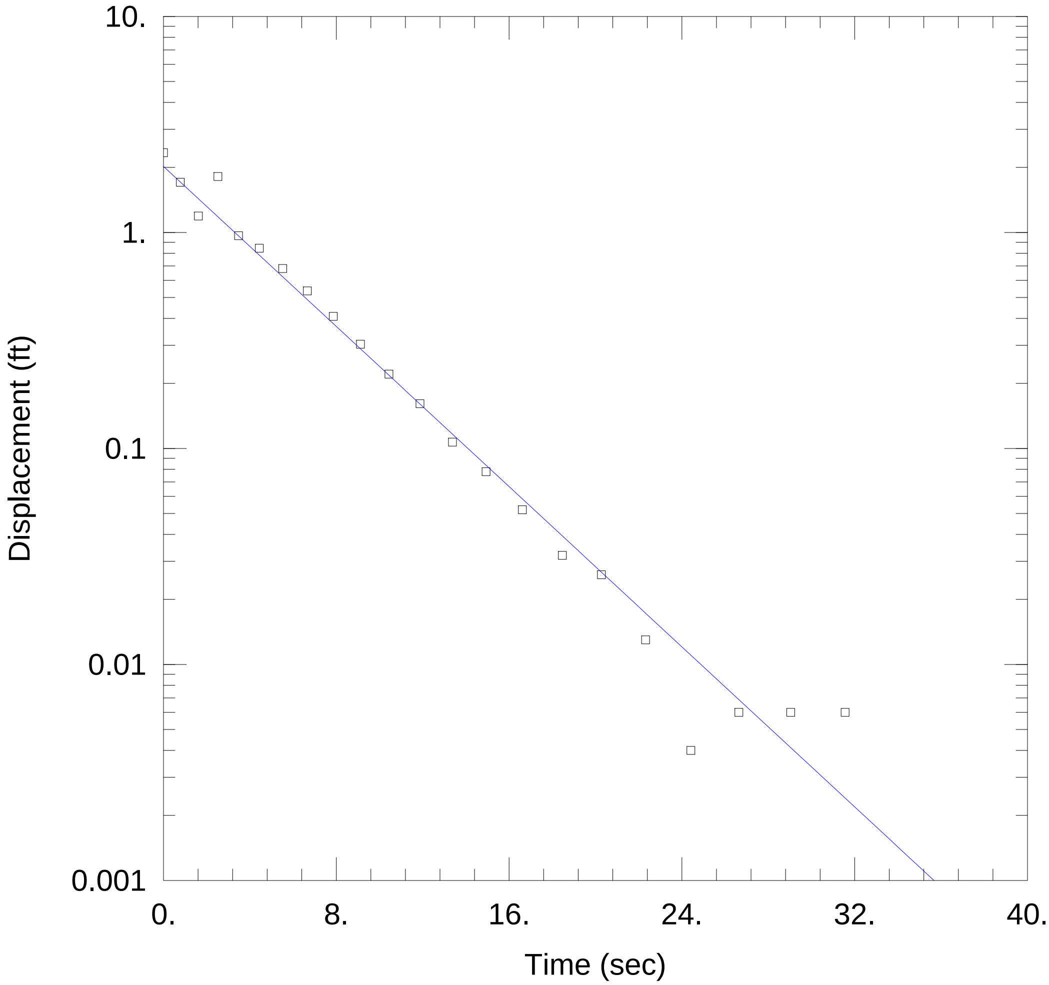
WELL DATA (PW-4)

Initial Displacement: 2.671 ft	Static Water Column Height: 26.85 ft
Total Well Penetration Depth: 25.85 ft	Screen Length: 15. ft
Casing Radius: 0.166 ft	Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.3023 ft/day y0 = 2.371 ft



FALLING HEAD

Data Set: P:\...\PW-5 Falling Head 1.aqt
Date: 02/23/16 | Time: 16:20:26

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-5
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 36.67 ft
Anisotropy Ratio (Kz/Kr): 0.1

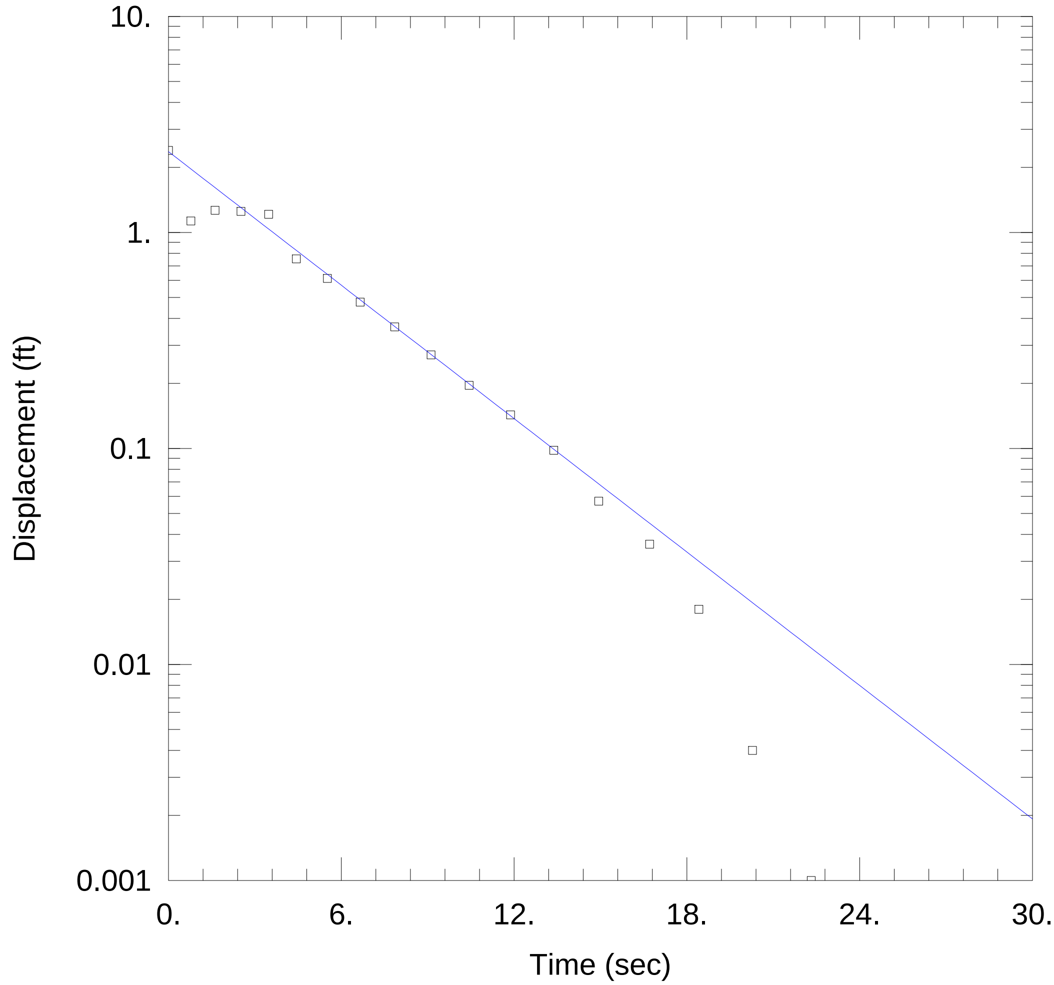
WELL DATA (PW-5)

Initial Displacement: 2.339 ft
Static Water Column Height: 31.67 ft
Total Well Penetration Depth: 30.67 ft
Screen Length: 15. ft
Casing Radius: 0.166 ft
Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 59.11 ft/day
y0 = 2.023 ft



FALLING HEAD 2

Data Set: P:\...\PW-5 Falling Head 2.aqt
Date: 02/23/16 Time: 16:20:43

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-5
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 36.37 ft Anisotropy Ratio (Kz/Kr): 0.1

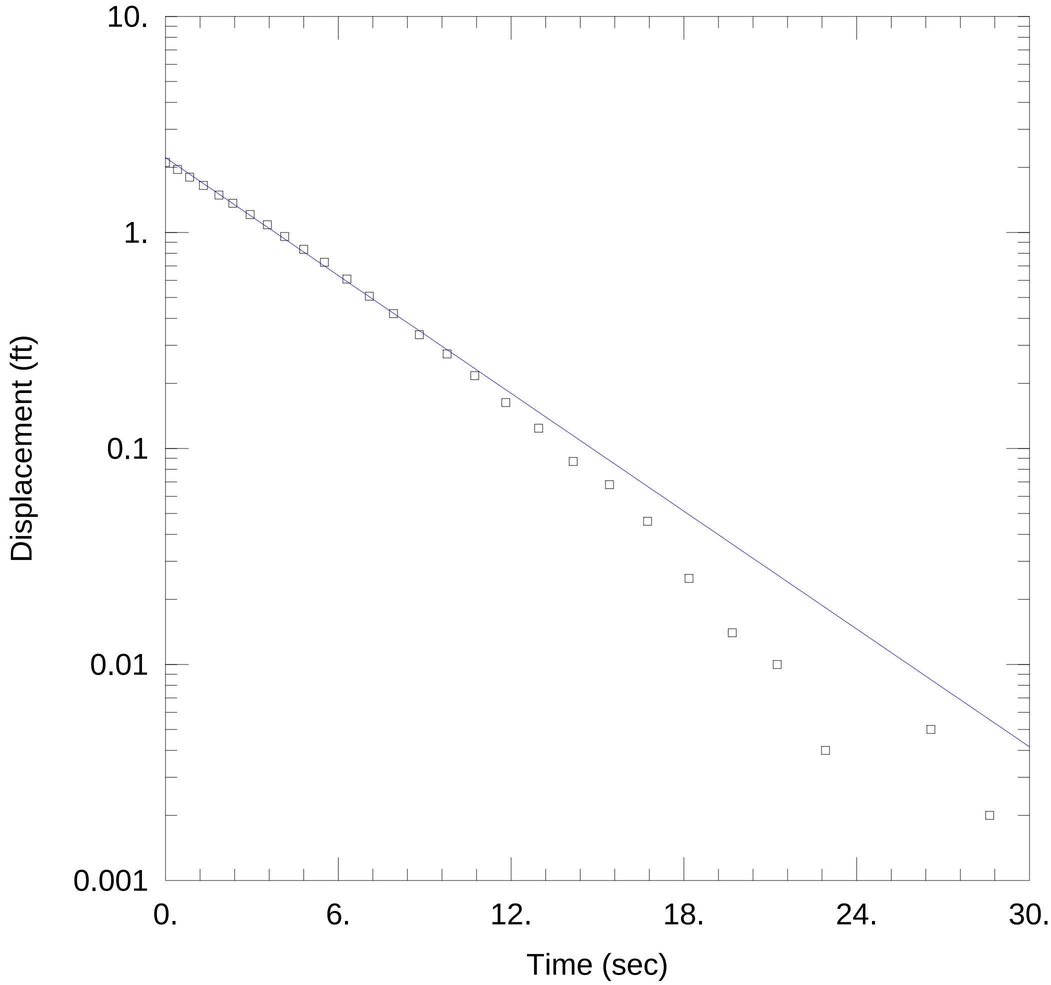
WELL DATA (PW-5)

Initial Displacement: 2.396 ft Static Water Column Height: 31.67 ft
Total Well Penetration Depth: 30.67 ft Screen Length: 15. ft
Casing Radius: 0.166 ft Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 65.78 ft/day y0 = 2.365 ft



RISING HEAD

Data Set: P:\...\PW-5 Rising Head 1.aqt
Date: 02/23/16
Time: 16:21:29

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-5
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 36.67 ft
Anisotropy Ratio (Kz/Kr): 0.1

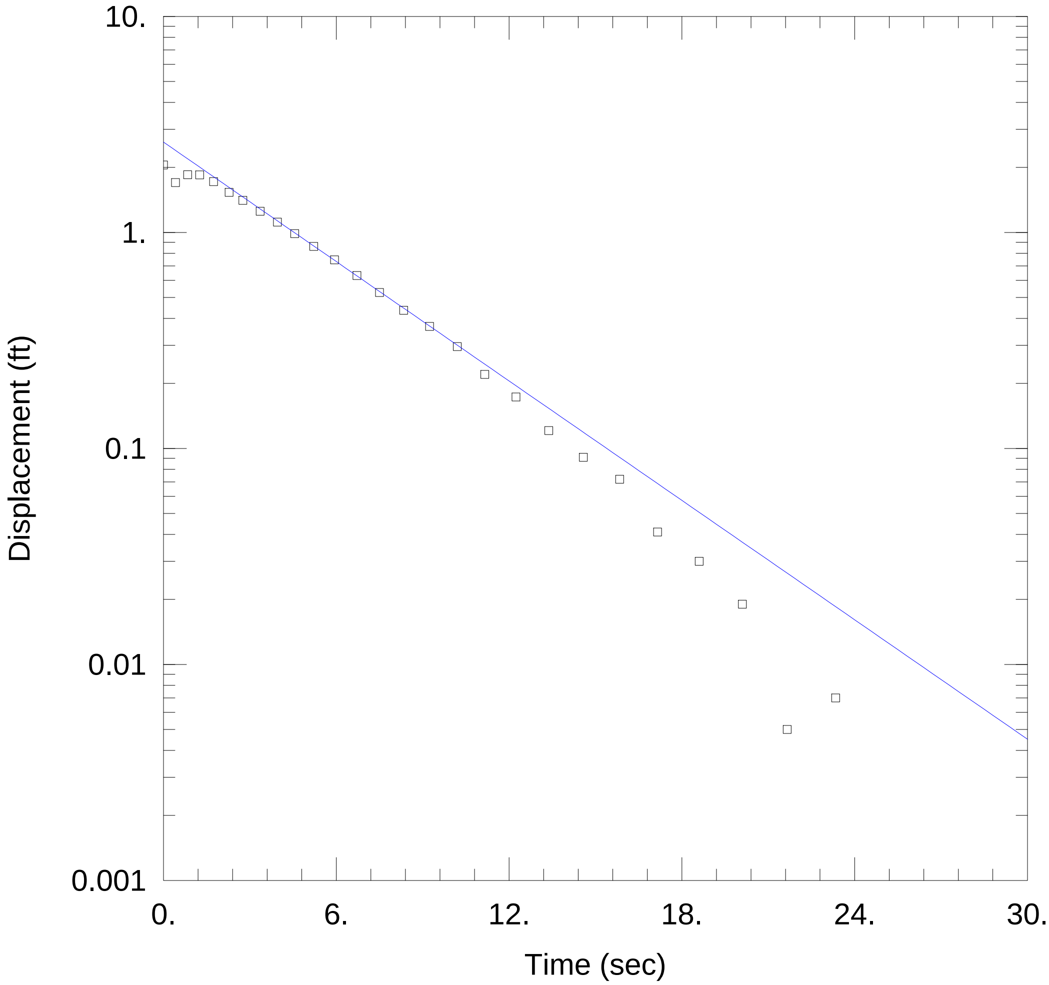
WELL DATA (PW-5)

Initial Displacement: 2.109 ft
Total Well Penetration Depth: 30.67 ft
Casing Radius: 0.166 ft
Static Water Column Height: 31.67 ft
Screen Length: 15. ft
Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 58.01 ft/day
y0 = 2.218 ft



RISING HEAD 2

Data Set: P:\...\PW-5 Rising Head 2.aqt
Date: 02/23/16 Time: 16:21:49

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-5
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 36.67 ft Anisotropy Ratio (Kz/Kr): 0.1

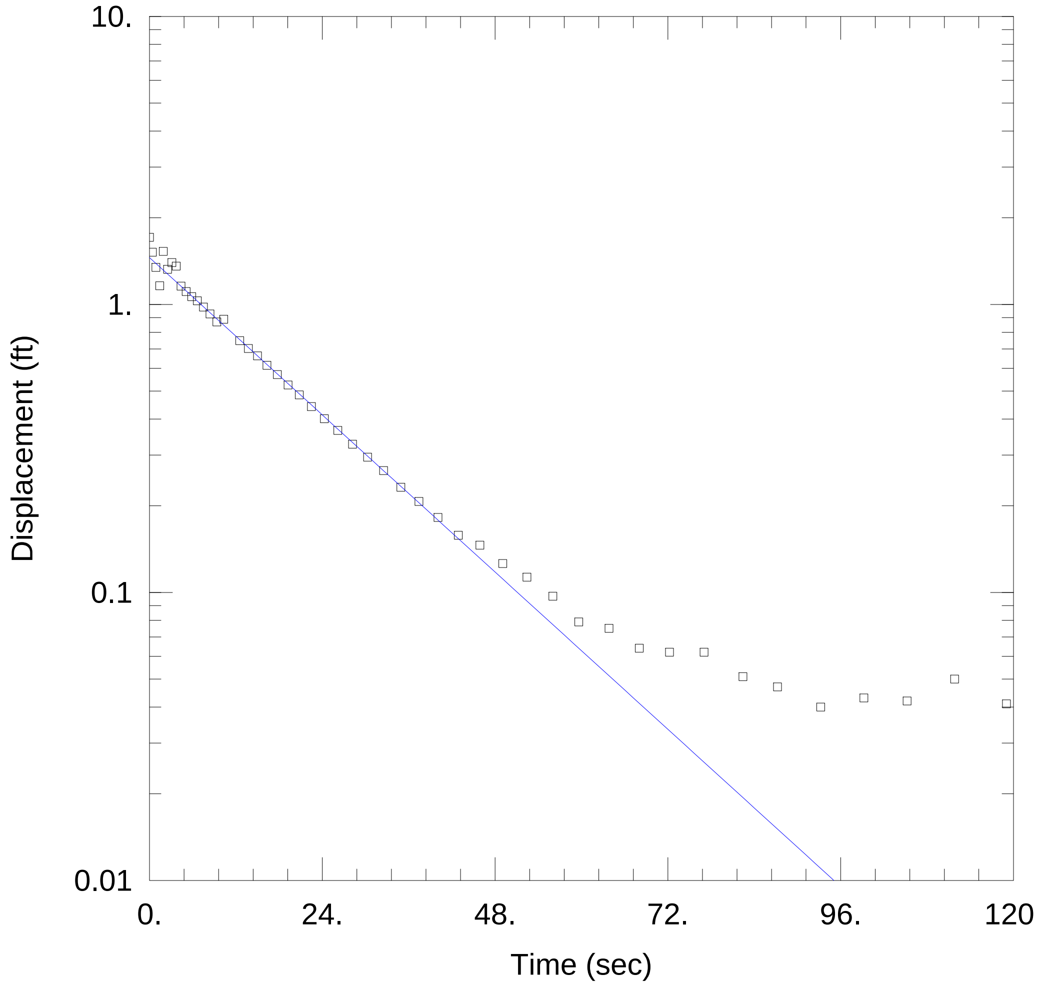
WELL DATA (PW-5)

Initial Displacement: 2.051 ft Static Water Column Height: 31.67 ft
Total Well Penetration Depth: 30.67 ft Screen Length: 15. ft
Casing Radius: 0.166 ft Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 58.79 ft/day y0 = 2.619 ft



FALLING HEAD

Data Set: P:\...\PW-6 Falling Head 1.aqt
Date: 02/23/16 Time: 16:22:07

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-6
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 32.34 ft Anisotropy Ratio (Kz/Kr): 0.1

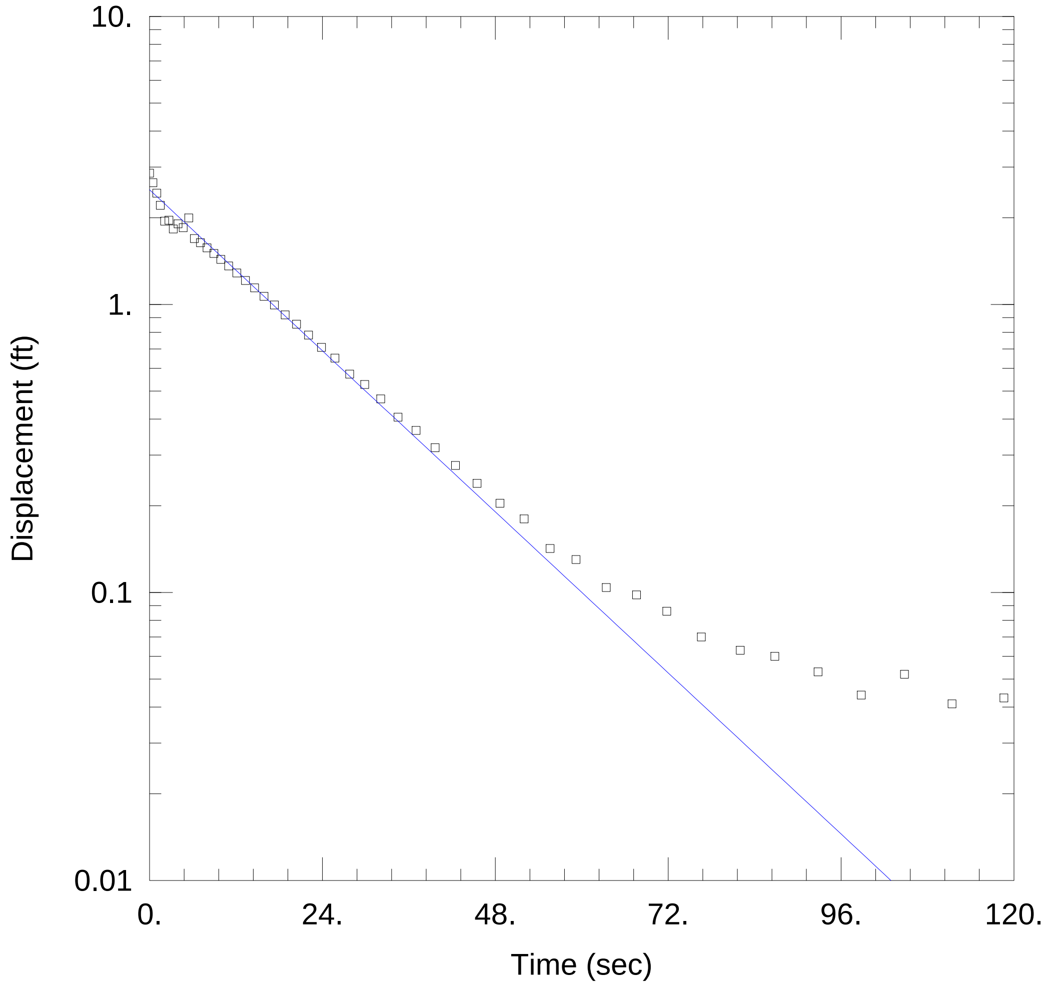
WELL DATA (PW-6)

Initial Displacement: 1.71 ft Static Water Column Height: 27.34 ft
Total Well Penetration Depth: 26.34 ft Screen Length: 15. ft
Casing Radius: 0.166 ft Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 14.22 ft/day y0 = 1.454 ft



FALLING HEAD 2

Data Set: P:\...\PW-6 Falling Head 2.aqt
Date: 02/23/16
Time: 16:22:23

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-6
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 32.34 ft
Anisotropy Ratio (Kz/Kr): 0.1

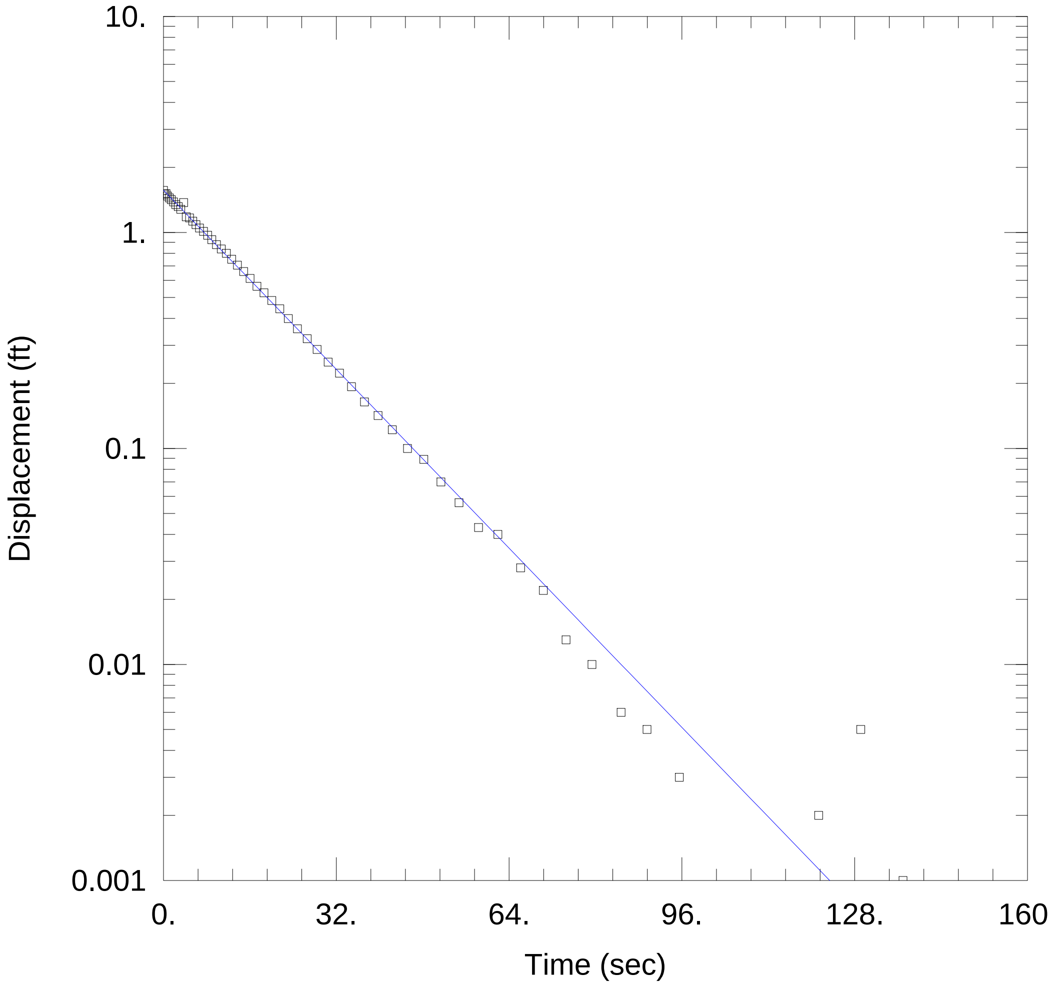
WELL DATA (PW-6)

Initial Displacement: 2.858 ft
Static Water Column Height: 27.34 ft
Total Well Penetration Depth: 26.34 ft
Screen Length: 15. ft
Casing Radius: 0.166 ft
Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 14.56 ft/day
y0 = 2.501 ft



RISING HEAD

Data Set: P:\...\PW-6 Rising Head 1.aqt
Date: 02/23/16 Time: 16:23:11

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-6
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 32.34 ft Anisotropy Ratio (Kz/Kr): 0.1

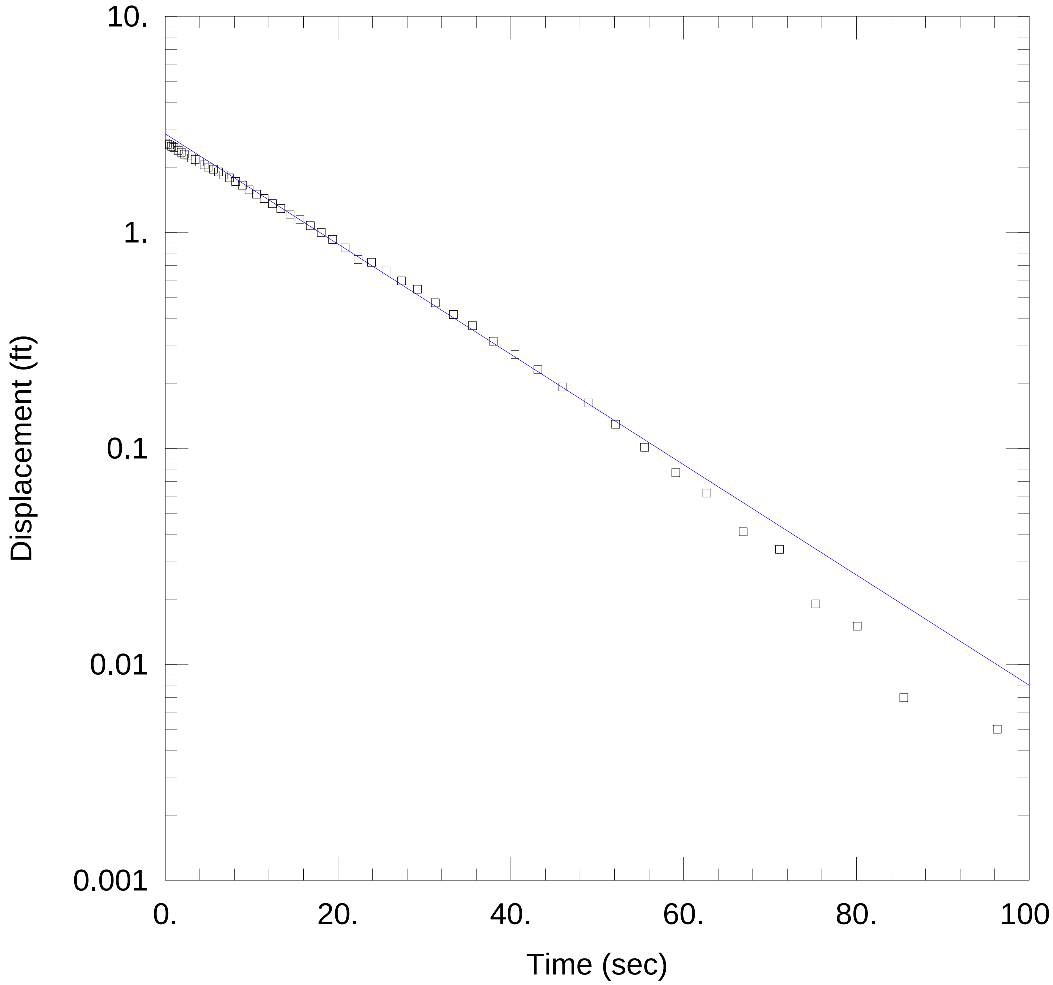
WELL DATA (PW-6)

Initial Displacement: 1.566 ft Static Water Column Height: 27.34 ft
Total Well Penetration Depth: 26.34 ft Screen Length: 15. ft
Casing Radius: 0.166 ft Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 16.18 ft/day y0 = 1.567 ft



RISING HEAD 2

Data Set: P:\...\PW-6 Rising Head 2.aqt
Date: 02/23/16 Time: 16:23:25

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-6
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 32.34 ft Anisotropy Ratio (Kz/Kr): 0.1

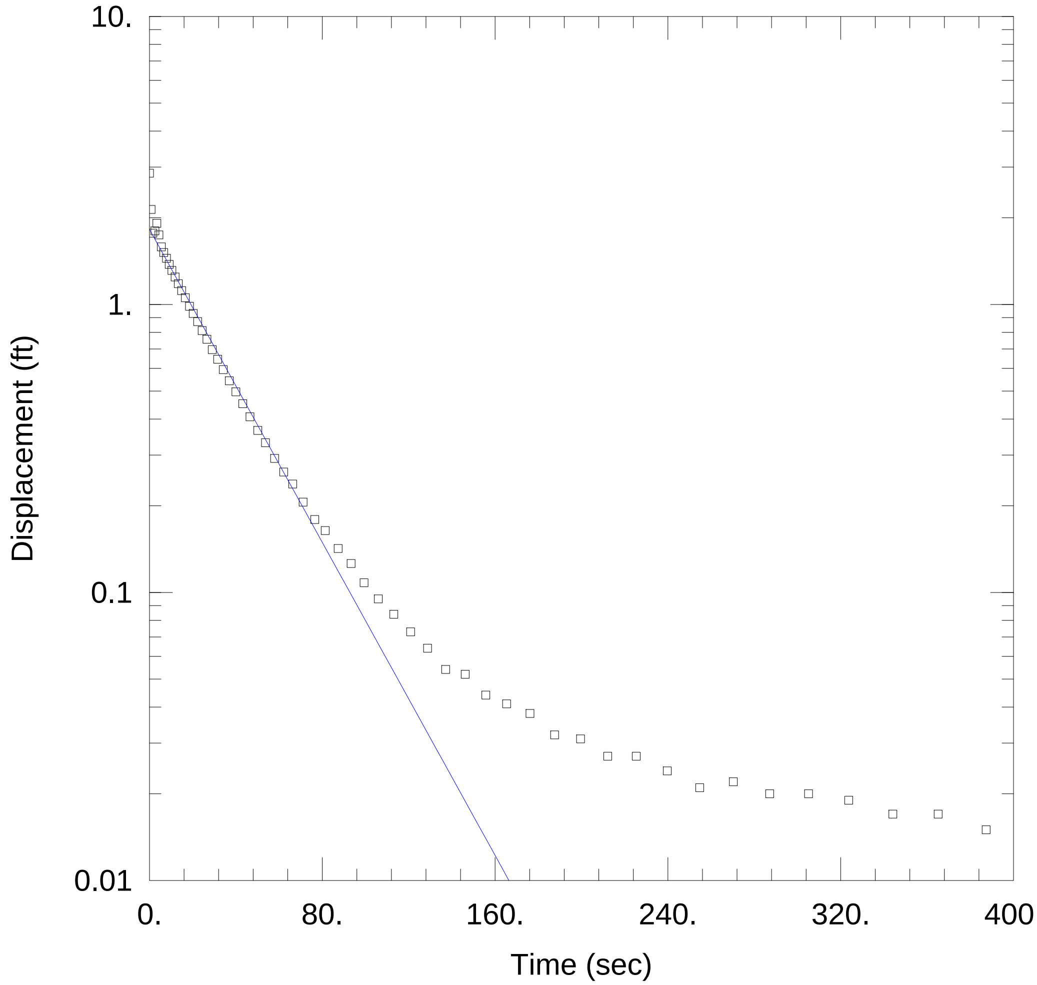
WELL DATA (PW-6)

Initial Displacement: 2.582 ft
Total Well Penetration Depth: 26.34 ft
Casing Radius: 0.166 ft
Static Water Column Height: 27.34 ft
Screen Length: 15. ft
Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 15.96 ft/day y0 = 2.854 ft



FALLING HEAD

Data Set: P:\...\PW-12 Falling Head 1.aqt
Date: 02/23/16
Time: 16:23:43

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-12
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 31.77 ft
Anisotropy Ratio (Kz/Kr): 0.1

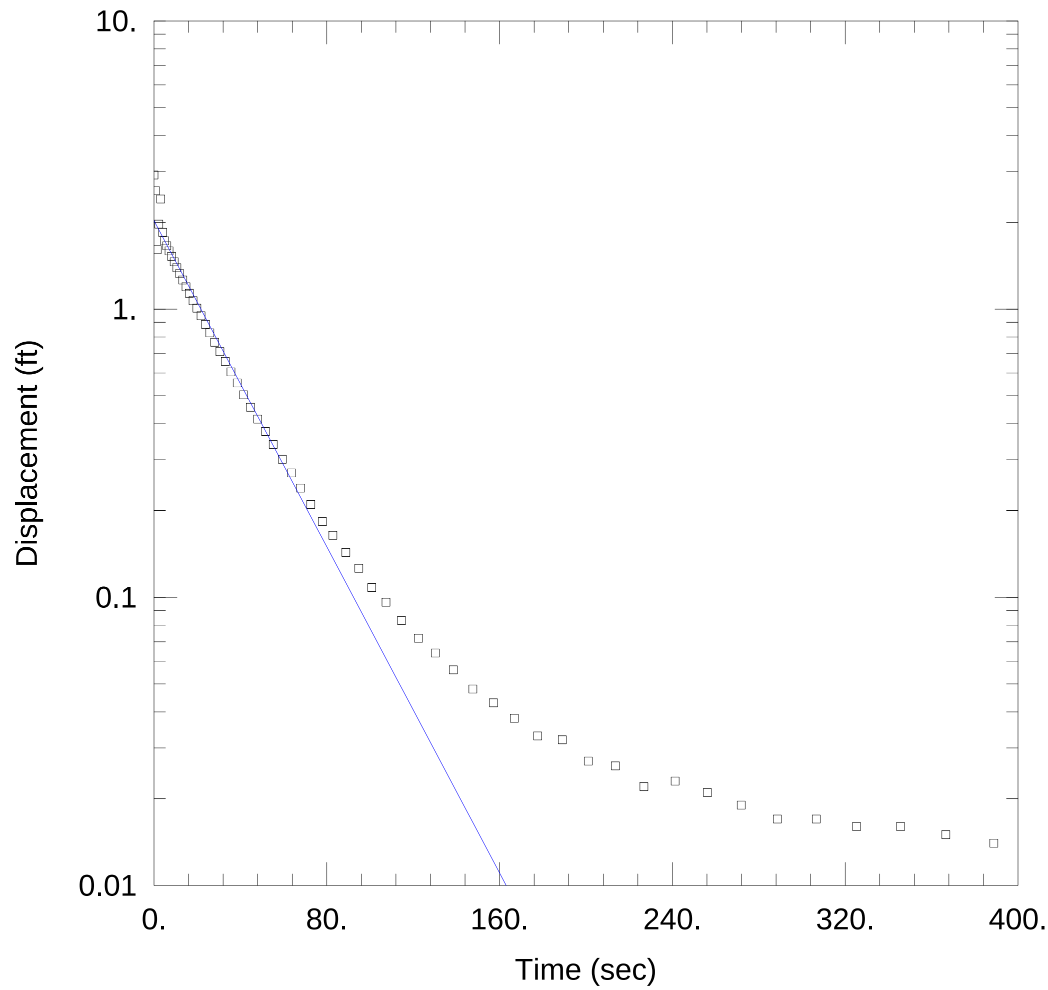
WELL DATA (PW-12)

Initial Displacement: 2.855 ft
Static Water Column Height: 23.77 ft
Total Well Penetration Depth: 23.57 ft
Screen Length: 15. ft
Casing Radius: 0.083 ft
Well Radius: 0.34 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 1.329 ft/day
y0 = 1.822 ft



FALLING HEAD 2

Data Set: P:\...\PW-12 Falling Head 2.aqt
Date: 02/23/16 Time: 16:24:36

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-12
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 31.77 ft Anisotropy Ratio (Kz/Kr): 0.1

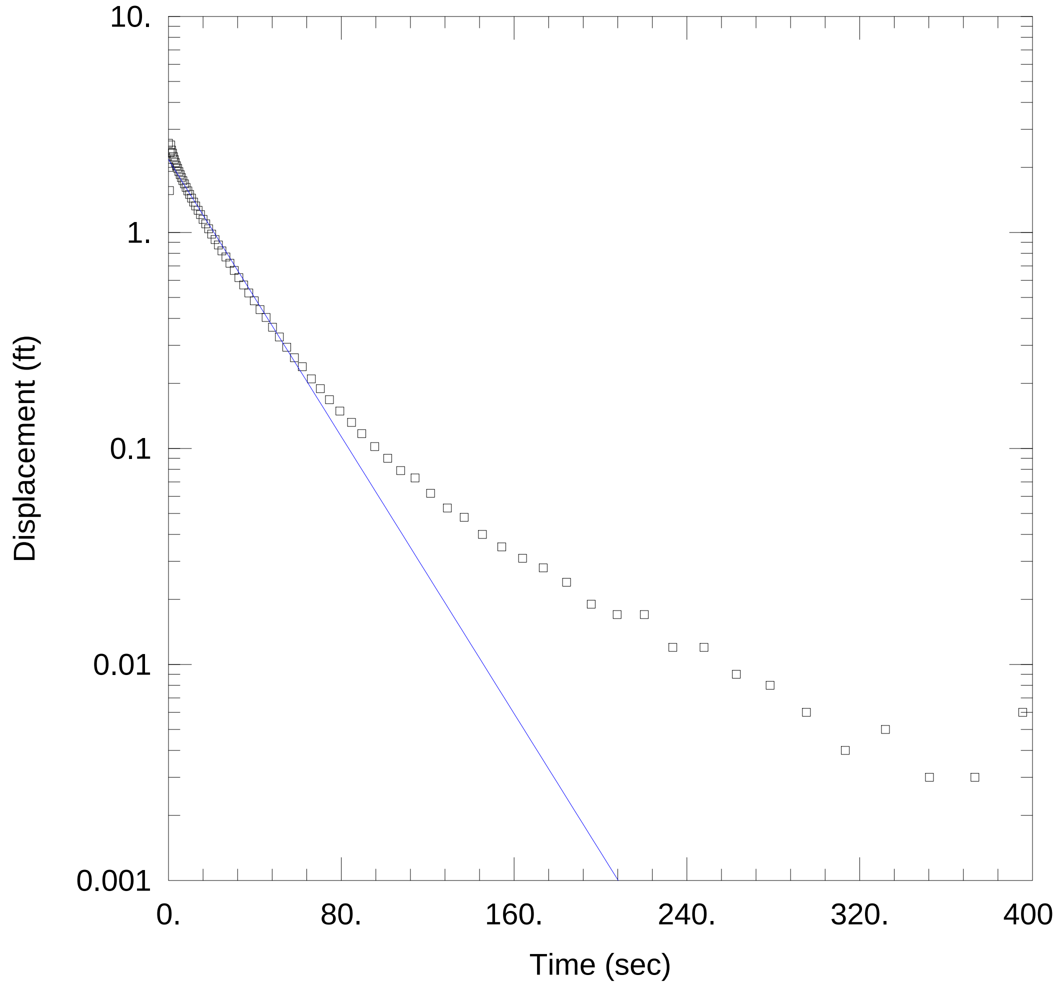
WELL DATA (PW-12)

Initial Displacement: 2.918 ft
Total Well Penetration Depth: 23.57 ft
Casing Radius: 0.083 ft
Static Water Column Height: 23.77 ft
Screen Length: 15. ft
Well Radius: 0.34 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 1.384 ft/day
y0 = 2.028 ft



RISING HEAD

Data Set: P:\...\PW-12 Rising Head 1.aqt
Date: 02/23/16 Time: 16:24:50

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-12
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 31.77 ft Anisotropy Ratio (Kz/Kr): 0.1

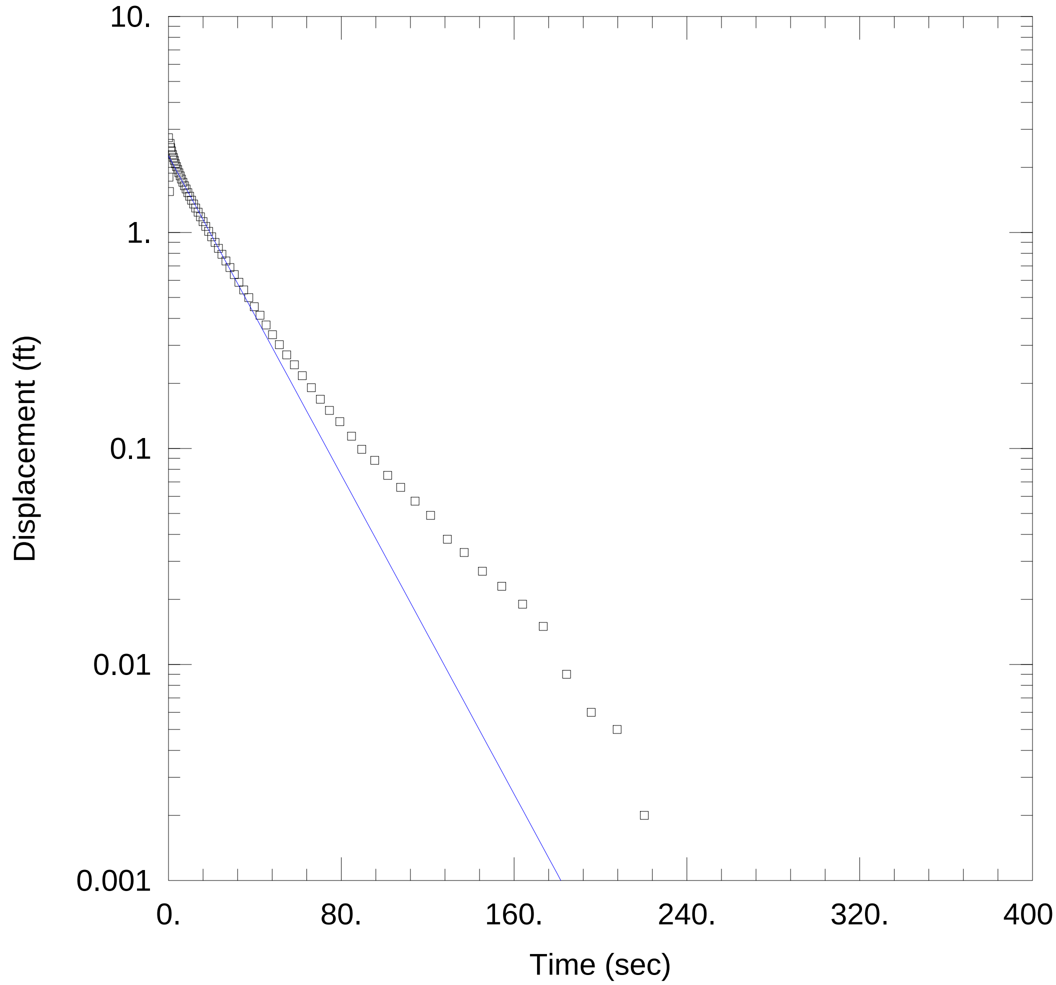
WELL DATA (PW-12)

Initial Displacement: 2.586 ft Static Water Column Height: 23.77 ft
Total Well Penetration Depth: 23.57 ft Screen Length: 15. ft
Casing Radius: 0.083 ft Well Radius: 0.34 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 1.568 ft/day y0 = 2.173 ft



RISING HEAD 2

Data Set: P:\...\PW-12 Rising Head 2.aqt
Date: 02/23/16 Time: 16:25:09

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-12
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 31.77 ft Anisotropy Ratio (Kz/Kr): 0.1

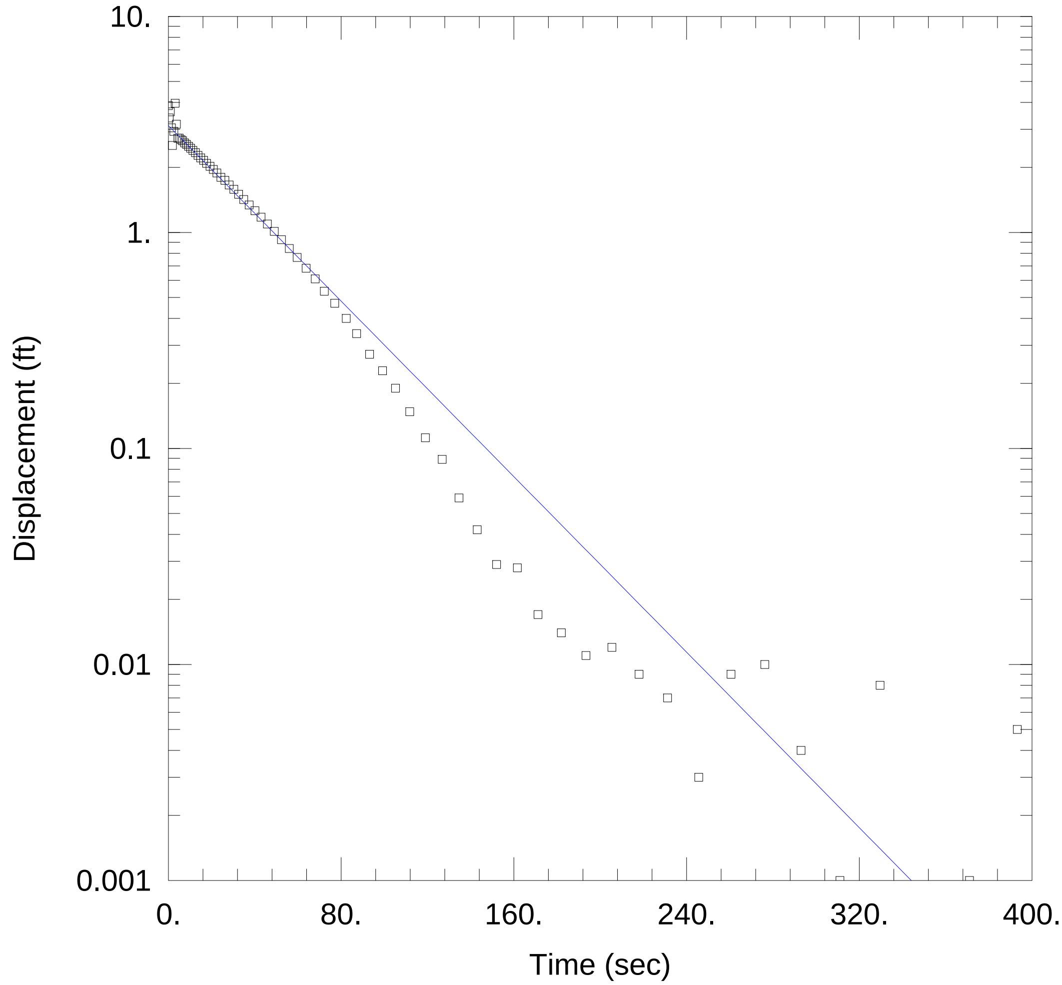
WELL DATA (PW-12)

Initial Displacement: 2.743 ft Static Water Column Height: 23.77 ft
Total Well Penetration Depth: 23.57 ft Screen Length: 15. ft
Casing Radius: 0.083 ft Well Radius: 0.34 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 1.807 ft/day y0 = 2.261 ft



FALLING HEAD

Data Set: P:\...\PW-13 Falling Head 1.aqt
Date: 02/23/16 Time: 16:25:20

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-13
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 24.55 ft Anisotropy Ratio (Kz/Kr): 0.1

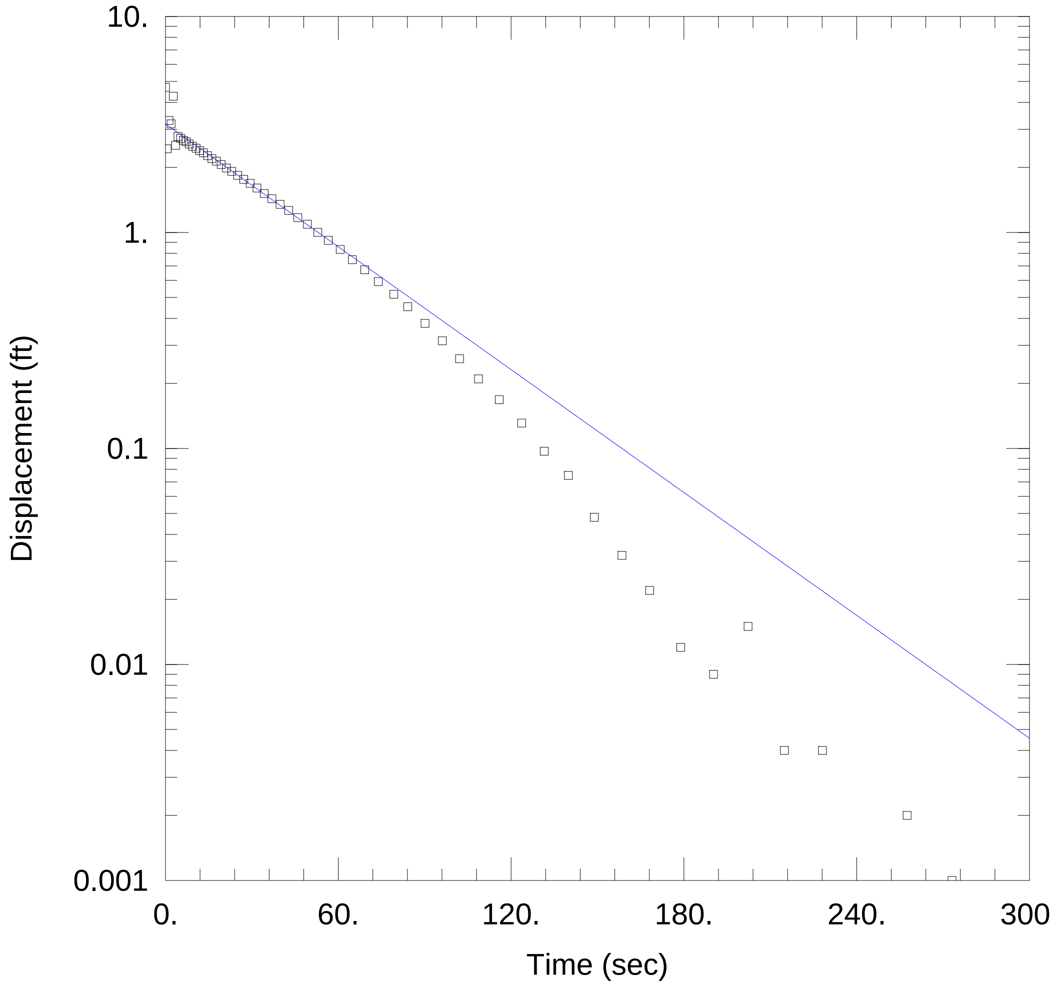
WELL DATA (PW-13)

Initial Displacement: 3.865 ft
Total Well Penetration Depth: 24.35 ft
Casing Radius: 0.083 ft
Static Water Column Height: 24.55 ft
Screen Length: 15. ft
Well Radius: 0.34 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 1.096 ft/day y0 = 3.122 ft



FALLING HEAD 2

Data Set: P:\...\PW-13 Falling Head 2.aqt
Date: 02/23/16
Time: 16:25:31

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-13
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 24.55 ft
Anisotropy Ratio (Kz/Kr): 0.1

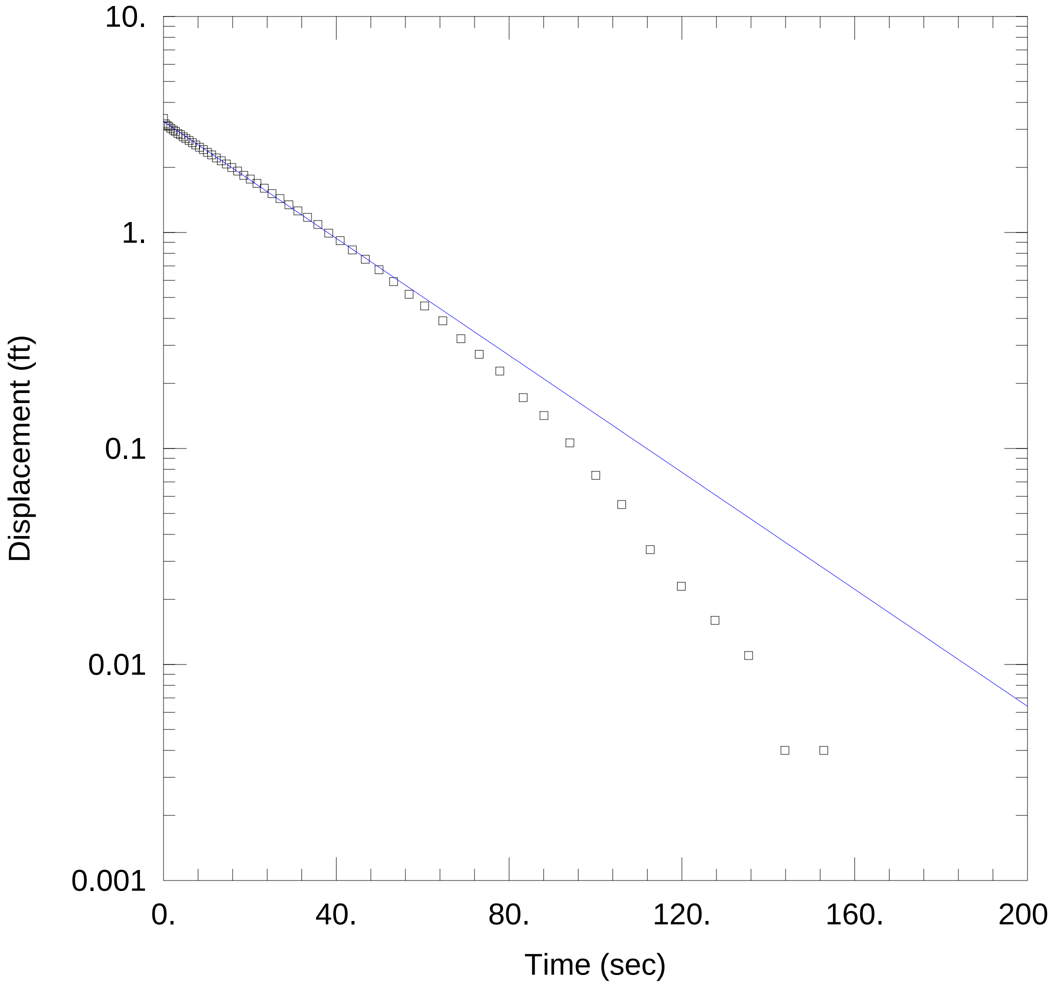
WELL DATA (PW-13)

Initial Displacement: 4.702 ft
Static Water Column Height: 24.55 ft
Total Well Penetration Depth: 24.35 ft
Screen Length: 15. ft
Casing Radius: 0.083 ft
Well Radius: 0.34 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 1.023 ft/day
y0 = 3.18 ft



RISING HEAD

Data Set: P:\...\PW-13 Rising Head 1.aqt
Date: 02/23/16 Time: 16:25:42

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-13
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 24.55 ft Anisotropy Ratio (Kz/Kr): 0.1

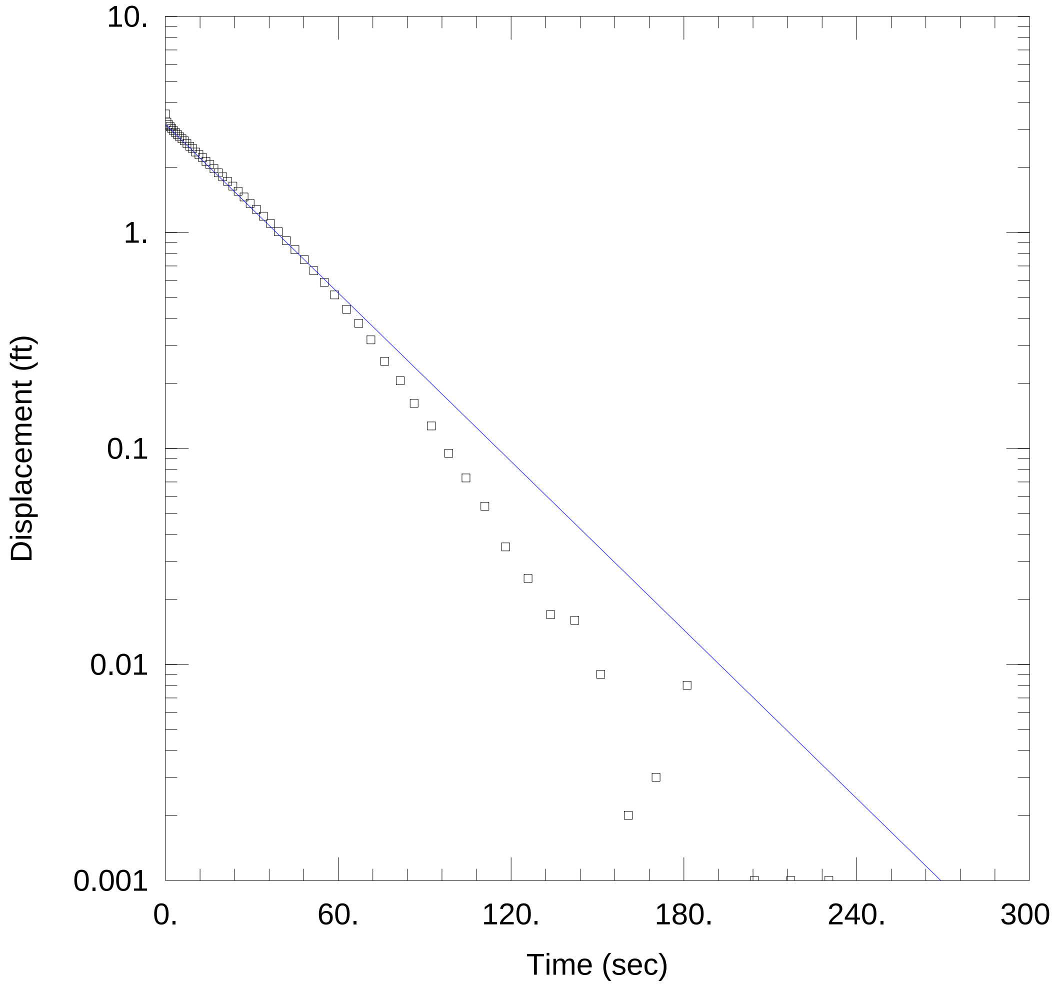
WELL DATA (PW-13)

Initial Displacement: 3.371 ft Static Water Column Height: 24.55 ft
Total Well Penetration Depth: 24.35 ft Screen Length: 15. ft
Casing Radius: 0.083 ft Well Radius: 0.34 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 1.461 ft/day y0 = 3.266 ft



RISING HEAD 2

Data Set: P:\...\PW-13 Rising Head 2.aqt
Date: 02/23/16 | Time: 16:25:57

PROJECT INFORMATION

Company: TRC
Client: Dominion Clover
Project: 232002
Test Well: PW-13
Test Date: 2/11/2016

AQUIFER DATA

Saturated Thickness: 24.55 ft | Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (PW-13)

Initial Displacement: 3.538 ft | Static Water Column Height: 24.55 ft
Total Well Penetration Depth: 24.35 ft | Screen Length: 15. ft
Casing Radius: 0.083 ft | Well Radius: 0.34 ft

SOLUTION

Aquifer Model: Unconfined | Solution Method: Bouwer-Rice

K = 1.403 ft/day | y0 = 3.162 ft

Appendix C
Hydraulic Gradient and Groundwater Flow Rate Calculations

Project Name: Dominion, Clover, Virginia Site
Date: February 8, 2016

HORIZONTAL GRADIENT CALCULATION

$$i = (h^1 - h^2)/S$$

Where:

i = Horizontal gradient (unitless)
h^1 = Water elevation in well 1 (ft)
h^2 = Water elevation in well 2 (ft)
S = Horizontal distance between well 1 and well 2 (ft)

Well 1 I.D.	Well 2 I.D.	Water Elevation Well 1 (ft)	Water Elevation Well 2 (ft)	Distance between Well 1 and Well 2 (ft)	Hydraulic Gradient
PW-1	PW-7	359.81	348.83	680	0.0161
PW-2	PW-13	357.17	348.11	660	0.0137
355 Contour	PW-6	355	348.56	330	0.0195
				Average:	**0.0165**

SEEPAGE VELOCITY CALCULATIONS

$$Vs = Ki/n_e$$

Where:

Vs = Seepage velocity
K = Hydraulic conductivity (ft/day)
i = Hydraulic gradient
n_e = effective porosity

Geologic Material	Hydraulic Conductivity (ft/day)	Hydraulic Gradient	Effective Porosity (estimated)	Estimated Seepage Velocity (ft/day)	Estimated Seepage Velocity (ft/yr)
Silty Clay/clayey silt	0.29	0.0165	0.423	0.011	4
Silty Clay/clayey silt	0.39	0.0165	0.423	0.015	6
Silty sand	1.25	0.0165	0.330	0.062	23
Silty sand	1.52	0.0165	0.330	0.076	28
Silty sand/weathered rock	15.23	0.0165	0.480	0.522	191
Silty sand/weathered rock	60.42	0.0165	0.480	2.072	756

Reference for effective porosity: Sara, Martin N., *Standard Handbook for Solid and Hazardous Waste Facility Assessment,* Lewis Publishers, 1994.

Project Name: Dominion, Clover, Virginia Site
Date: February 8, 2016

RESULTS OF HYDRAULIC CONDUCTIVITY TESTING (SLUG TESTS)

WATER TABLE AQUIFER WELLS			
WELL	**GEOLOGIC MATERIAL**	**ESTIMATED K (ft/day)**	**PER WELL AVERAGE K (ft/day)**
PW-2 (FH)	SILTY CLAY/CLAYEY SILT	0.38	0.39
PW-2 (RH)	SILTY CLAY/CLAYEY SILT	0.40	
PW-3 (FH)	SILTY SAND	1.38	1.46
PW-3 (RH)	SILTY SAND	1.53	
PW-4 (FH)	SILTY CLAY/CLAYEY SILT	0.27	0.29
PW-4 (RH)	SILTY CLAY/CLAYEY SILT	0.30	
PW-5 (FH)	SILTY SAND/WEATHERED ROCK	59.11	60.42
PW-5 (FH)*	SILTY SAND/WEATHERED ROCK	65.78	
PW-5 (RH)	SILTY SAND/WEATHERED ROCK	58.01	
PW-5 (RH)*	SILTY SAND/WEATHERED ROCK	58.79	
PW-6 (FH)	SILTY SAND/WEATHERED ROCK	14.22	15.23
PW-6 (FH)*	SILTY SAND/WEATHERED ROCK	14.56	
PW-6 (RH)	SILTY SAND/WEATHERED ROCK	16.18	
PW-6 (RH)*	SILTY SAND/WEATHERED ROCK	15.96	
PW-12 (FH)	SILTY SAND	1.33	1.52
PW-12 (FH)*	SILTY SAND	1.38	
PW-12 (RH)	SILTY SAND	1.57	
PW-12 (RH)*	SILTY SAND	1.81	
PW-13 (FH)	SILTY SAND	1.10	1.25
PW-13 (FH)*	SILTY SAND	1.02	
PW-13 (RH)	SILTY SAND	1.46	
PW-13 (RH)*	SILTY SAND	1.40	

(FH) Falling Head Test

(RH) Rising Head Test

* Results for second Falling Head or Rising Head Test

Appendix D
Soil Boring Logs and Well Construction Diagrams

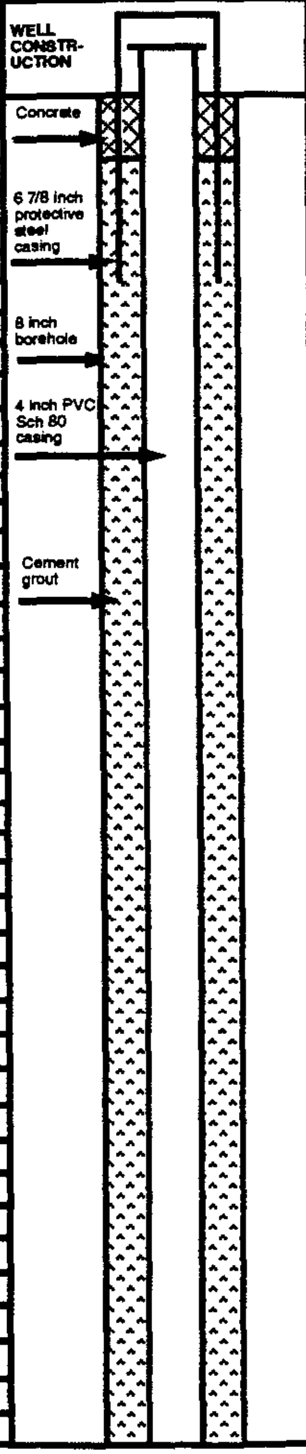
TEST BORING - WELL CONSTRUCTION LOG

PROJECT Old Dominion Electric Cooperative - Clover, Virginia	BORING NO. PW-1
CLIENT H.B. Zachry Company and Black & Veatch	SHEET 1 OF 3
DRILLING CONTRACTOR Bore and Core	JOB NO. 931010
PURPOSE Upgradient Well for Coal Pile/ Limestone Runoff Pond	ELEV. MP / GR

GROUND WATER					CASING	SAMPLE	CORE	WELL	DATUM
DATE	TIME	DEPTH	CASING	TYPE					STARTED 10/29/93
				DIAMETER					COMPLETED 11/04/93
				WEIGHT				DRILLER	Dubesky/Cassell
				FALL				GEOLOGIST	M.Armstrong (#710)

DEPTH FEET	SAMPLE NUMBER	BLOWS PER 6"	IDENTIFICATION	REMARKS
				CME 75 rig drilled borehole using 6 1/4 inch O.D. 3 1/8 inch I.D. hollow stem augers
	S-1	10 9 11	Tan to yellow brown silty clay (CL) dry	
5				
	S-2	17 21 30	Red brown clayey silt (ML) dry	
10				
	S-3	34 30 34	Red brown to tan clayey silt (ML) dry	
15				
	S-4	25 50/5"	Red brown clayey silt (ML) dry	
20				

WELL CONSTRUCTION



TEST BORING - WELL CONSTRUCTION LOG

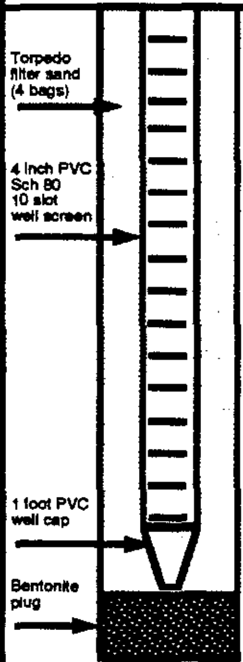
PROJECT	Old Dominion Electric Cooperative - Clover, Virginia	**BORING NO.**	PW-1
CLIENT	H.B. Zachry Company and Black & Veatch	**JOB NO.** 931010	**SHEET 2 OF** 3

DEPTH FEET	SAMPLE NUMBER	BLOWS PER 6"	WELL CONSTRUCTION	IDENTIFICATION	REMARKS
			Cement grout		Hard drilling at 22 feet
	S-5	50/5"		Black silty sand (SM) dry (partially weathered rock)	
25					
	S-6	50/4"		Black silty sand (SM) dry, with pieces of rock (partially weathered rock)	
30					
	S-7	50/3"	Bentonite	No sample recovery	
35			T?pedo filter sand (4 bags)		
	S-8	50/4"	4 inch PVC Sch 80 10 slot well screen	Black silty sand (SM) moist (partially weathered rock) Terminated 6 1/4 inch borehole at 38.33 feet	
40					
45					

TEST BORING - WELL CONSTRUCTION LOG

PROJECT	Old Dominion Electric Cooperative - Clover, Virginia		**BORING NO.** PW-1
CLIENT	H.B. Zachry Company and Black & Veatch	**JOB NO.** 931010	**SHEET 3 OF** 3

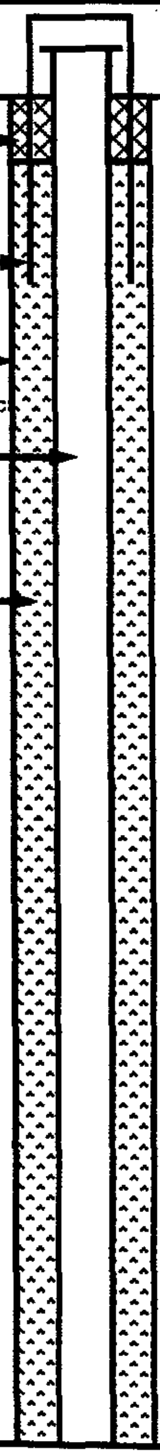
DEPTH FEET	SAMPLE NUMBER	BLOWS PER 6"	WELL CONSTRUCTION	IDENTIFICATION	REMARKS
50					
55					Failing F-7 drilling rig reamed 8 inch hole to 55 feet to set well casing. Used mud rotary drilling method.
60					
65					
70					



TEST BORING - WELL CONSTRUCTION LOG

PROJECT Old Dominion Electric Cooperative - Clover, Virginia	BORING NO. PW-2
CLIENT H.B. Zachry Company and Black & Veatch	SHEET 1 OF 2
DRILLING CONTRACTOR Bore and Core	JOB NO. 931010
PURPOSE Upgradient Well for Holding Pond and Sludge Ponds	ELEV. MP / GR

GROUND WATER					CASING	SAMPLE	CORE	WELL	DATUM
DATE	TIME	DEPTH	CASING	TYPE					STARTED 10/29/93
				DIAMETER					COMPLETED 11/5/93
				WEIGHT				DRILLER	Dubesky/Cassell
				FALL				GEOLOGIST	M.Armstrong (#710)



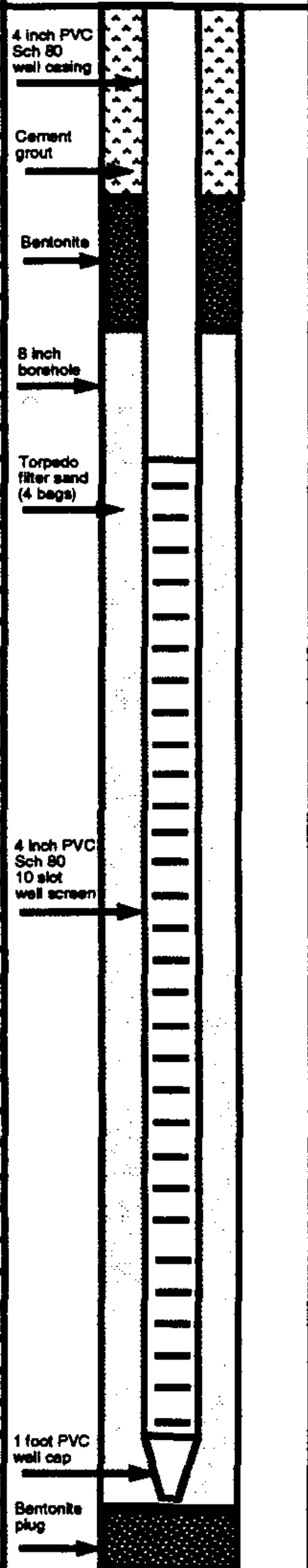
DEPTH FEET	SAMPLE NUMBER	BLOWS PER 6"	WELL CONSTRUCTION	IDENTIFICATION	REMARKS
			Concrete 6 7/8 inch protective steel casing		CME 75 rig drilled borehole using 6 1/4 inch O.D. 3 1/8 inch I.D. hollow stem augers
	S-1	10 14 11	8 inch borehole	Black and orange silty sand (ML) dry	
5			4 inch PVC Sch 80 casing Cement grout		
	S-2	4 4 5		Yellow brown to red brown silty clay (CL) slightly moist	
10					
	S-3	5 7 7		Orange to tan clayey silt (ML) moist	
15					
	S-4	4 4 5		Orange to yellow brown clayey silt with black streaks or layers (ML) wet	
20					

TEST BORING - WELL CONSTRUCTION LOG

PROJECT	Old Dominion Electric Cooperative - Clover, Virginia	BORING NO.	PW-2
CLIENT	H.B. Zachry Company and Black & Veatch	JOB NO. 931010	SHEET 2 OF 2

DEPTH FEET	SAMPLE NUMBER	BLOWS PER 6"	IDENTIFICATION	REMARKS
	S-5	5 7 12	Orange, yellow brown, pink clayey silt to silty clay (ML to CL) wet	
25				
	S-6	8 12 14	Brown and pink silty clay (CL) wet	
30				
	S-7	15 19 40	Gray, green, pink clayey silt (ML) wet	
35				
	S-8	12 20 27	Gray, green, black, orange clayey silt to silty clay (ML to CL) wet (partially weathered rock)	
40			Terminated 6 1/4" borehole at 39.5'	Failing F-7 drilling rig reamed 8 inch hole to 44 feet to set well casing. Used mud rotary drilling method.
45				

WELL CONSTRUCTION



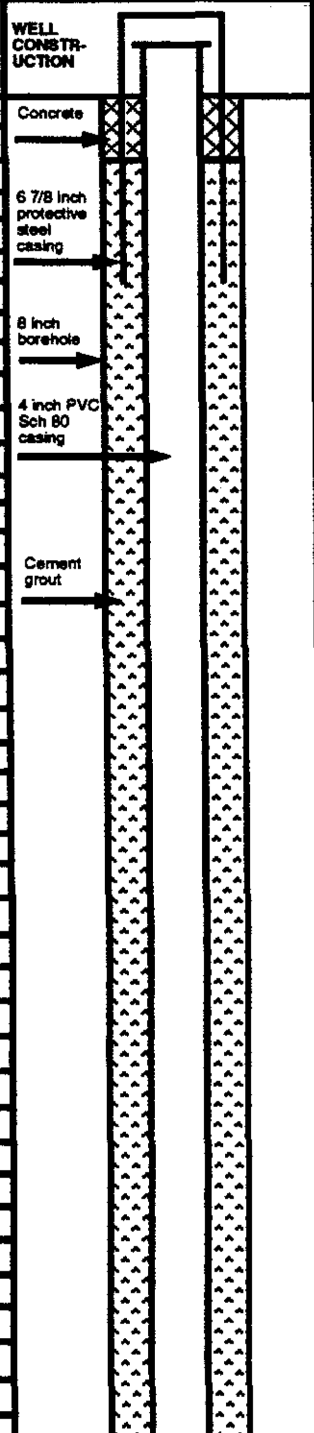
TEST BORING - WELL CONSTRUCTION LOG

PROJECT Old Dominion Electric Cooperative - Clover, Virginia	BORING NO. PW-3
CLIENT H.B. Zachry Company and Black & Veatch	SHEET 1 OF 3
DRILLING CONTRACTOR Bore and Core	JOB NO. 931010
PURPOSE Downgradient Well for Sludge Ponds	ELEV. MP / GR

GROUND WATER					CASING	SAMPLE	CORE	WELL	DATUM
DATE	TIME	DEPTH	CASING	TYPE					STARTED 10/29/93
				DIAMETER					COMPLETED 11/6/93
				WEIGHT				DRILLER Dubesky/Cassell	
				FALL				GEOLOGIST M.Armstrong (#710)	

DEPTH FEET	SAMPLE NUMBER	BLOWS PER 6"	IDENTIFICATION	REMARKS
				CME 75 rig drilled borehole using 6 1/4 inch O.D. 3 1/8 inch I.D. hollow stem augers
	S-1	6 8 10	Red brown silty clay (CL) dry	
5				
	S-2	4 4 4	Orange slightly clayey silt (ML) dry	
10				
	S-3	6 7 9	Light orange slightly clayey silt (ML) slightly moist	
15				
	S-4	8 9 10	Red brown to tan clayey silt (ML) moist	
20				

WELL CONSTRUCTION

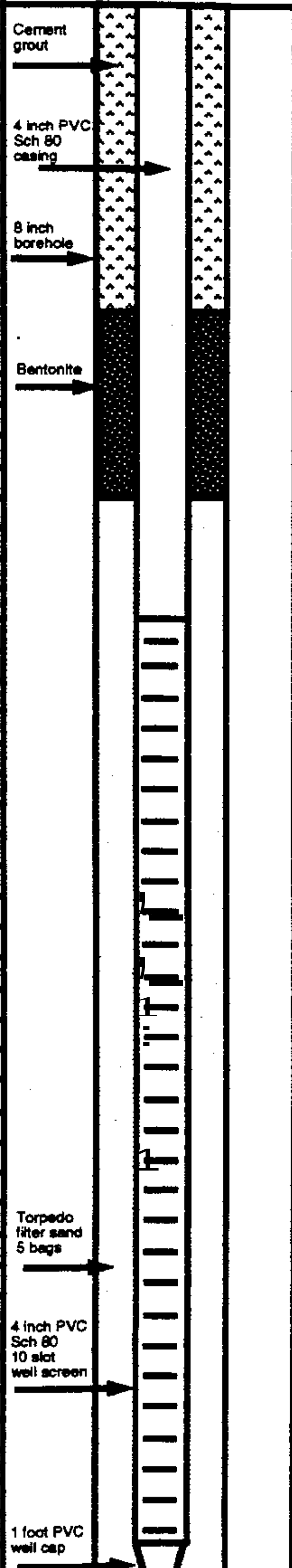


TEST BORING - WELL CONSTRUCTION LOG

PROJECT	Old Dominion Electric Cooperative - Clover, Virginia	**BORING NO.**	PW-3
CLIENT	H.B. Zachry Company and Black & Veatch	**JOB NO.** 931010	**SHEET 2 OF 3**

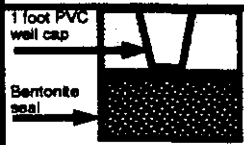
DEPTH FEET	SAMPLE NUMBER	BLOWS PER 6"	IDENTIFICATION	REMARKS
	S-5	8 12 15	Tan silty slightly clayey sand (SM) wet	
25				
	S-6	17 28 25	Tan brown silty clayey sand (SM) wet	
30				
	S-7	33 50/6"	Orange silty sand (SM) wet (partially weathered rock)	
35				
	S-8	50/6"	Orange silty sand (SM) wet (partially weathered rock) Terminated 6 1/4" borehole at 38.5'	Failing F-7 drilling rig reamed 8 inch hole to 47 feet to set well casing. Used mud rotary drilling method.
40				
45				

WELL CONSTRUCTION



TEST BORING - WELL CONSTRUCTION LOG

PROJECT	Old Dominion Electric Cooperative - Clover, Virginia		**BORING NO.**	PW-3
CLIENT	H.B. Zachry Company and Black & Veatch	**JOB NO.** 931010	**SHEET 3 OF**	3

DEPTH FEET	SAMPLE NUMBER	BLOWS PER 6"	WELL CONSTRUCTION	IDENTIFICATION	REMARKS
					Failing F-7 drilling rig reamed 8 inch hole to 47 feet to set well casing. Used mud rotary drilling method.
50					
55					
60					
65					
70					

TEST BORING - WELL CONSTRUCTION LOG

PROJECT Old Dominion Electric Cooperative - Clover, Virginia		**BORING NO.** PW-4
CLIENT H.B. Zachry Company and Black & Veatch		**SHEET 1 OF** 3
DRILLING CONTRACTOR Bore and Core		**JOB NO.** 931010
PURPOSE Down gradient Monitoring Well for Sludge Ponds		**ELEV.** MP GR

GROUND WATER					CASING	SAMPLE	CORE	WELL	DATUM
DATE	TIME	DEPTH	CASING	TYPE					STARTED 10/29/93
				DIAMETER					COMPLETED 11/8/93
				WEIGHT				DRILLER	Dubesky/Cassell
				FALL				GEOLOGIST	M.Armstrong (#710)

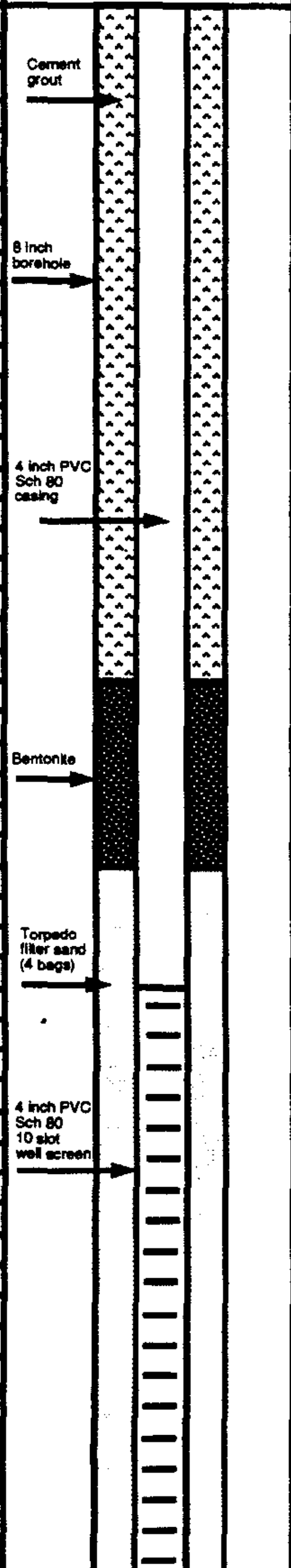
DEPTH FEET	SAMPLE NUMBER	BLOWS PER 6"	WELL CONSTRUCTION	IDENTIFICATION	REMARKS
			Concrete; 6 7/8 inch protective steel casing		CME 75 rig drilled borehole using 6 1/4 inch O.D. 3 1/8 inch I.D. hollow stem augers
	S-1	5, 6, 7	8 inch borehole	Red brown silty clay (CL) dry	
5			4 inch PVC Sch 80 casing; Cement grout		
	S-2	6, 12, 13		Red brown silty clay (CL) dry	
10					
	S-3	6, 8, 8		Red brown to yellow brown silty clay (CL) slightly moist	
15					
	S-4	9, 12, 15		Gray, green slightly clayey micaceous silt (ML) slightly moist	
20					

TEST BORING - WELL CONSTRUCTION LOG

PROJECT	Old Dominion Electric Cooperative - Clover, Virginia		BORING NO. PW-4
CLIENT	H.B. Zachry Company and Black & Veatch	JOB NO. 931010	SHEET 2 OF 3

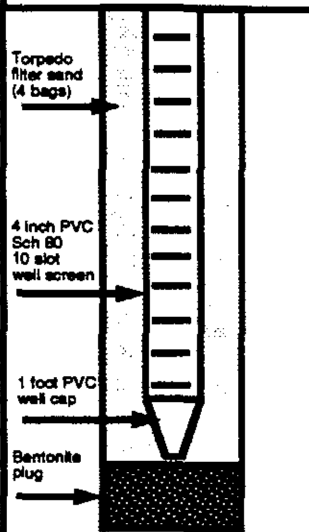
DEPTH FEET	SAMPLE NUMBER	BLOWS PER 6"	IDENTIFICATION	REMARKS
	S-5	12 16 22	Gray green slightly clayey micaceous silt (ML) slightly moist	
25				
	S-6	36 50/5"	Gray green slightly clayey micaceous silt (ML) slightly moist	
30				
	S-7	22 50/5"	Gray green slightly clayey micaceous silt (ML) slightly moist	
35				
	S-8	38 50/6"	Gray green slightly clayey micaceous silt (ML) slightly moist Terminated 6 1/4" borehole at 39.00'	
40				
45				

WELL CONSTRUCTION



TEST BORING - WELL CONSTRUCTION LOG

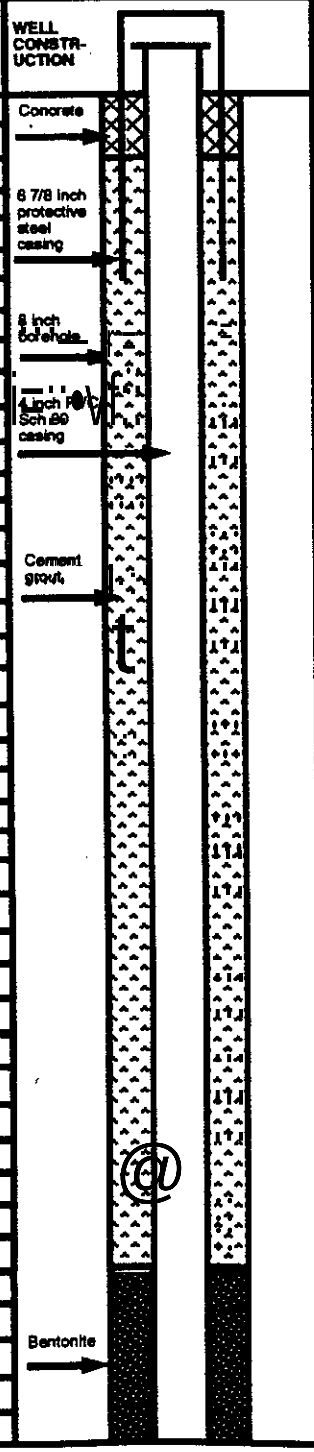
PROJECT	Old Dominion Electric Cooperative - Clover, Virginia		**BORING NO.**	PW-4
CLIENT	H.B. Zachry Company and Black & Veatch	**JOB NO.** 931010	**SHEET 3 OF**	3

DEPTH FEET	SAMPLE NUMBER	BLOWS PER 6"	WELL CONSTRUCTION	IDENTIFICATION	REMARKS
					Failing F-7 drilling rig reamed 8 inch hole to 53 feet to set well casing. Used mud rotary drilling method.
50					
55					
60					
65					
70					

TEST BORING - WELL CONSTRUCTION LOG

PROJECT Old Dominion Electric Cooperative - Clover, Virginia	**BORING NO.** PW-5
CLIENT H.B. Zachry Company and Black & Veatch	**SHEET 1 OF** 2
DRILLING CONTRACTOR Bore and Core	**JOB NO.** 931010
PURPOSE Downgradient Monitoring Well for Sludge Ponds	**ELEV.** MP / GR

GROUND WATER					CASING	SAMPLE	CORE	WELL	DATUM
DATE	TIME	DEPTH	CASING	TYPE					STARTED 10/29/93
				DIAMETER					COMPLETED 11/9/93
				WEIGHT				DRILLER	Dubesky/Cassell
				FALL				GEOLOGIST	M.Armstrong (#710)



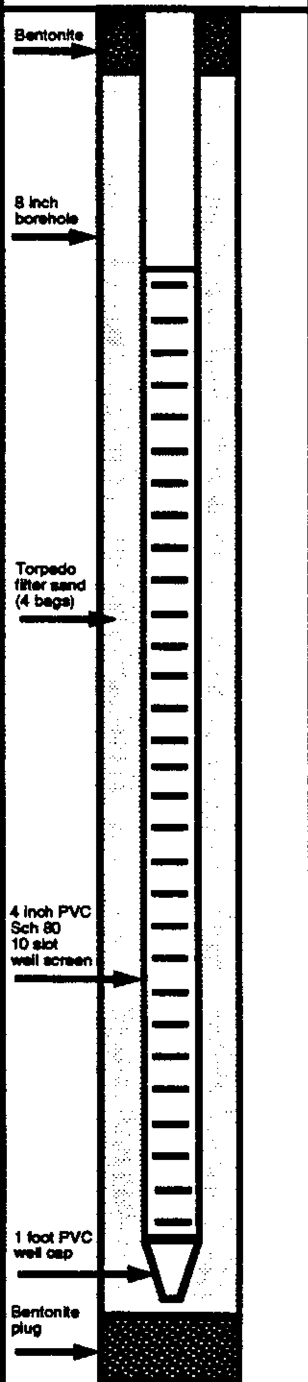
DEPTH FEET	SAMPLE NUMBER	BLOWS PER 6"	IDENTIFICATION	REMARKS
				CME 75 rig drilled borehole using 6 1/4 inch O.D. 3 1/8 inch I.D. hollow stem augers
	S-1	8 / 8 / 10	Yellow brown clayey silt (ML) slightly moist	
5				
	S-2	6 / 8 / 10	Yellow brown clayey silt to silty clay (ML to CL) slightly moist	
10				
	S-3	10 / 15 / 20	Light tan clayey sand to sandy clay (SC to CL) slightly moist	
15				
	S-4	50/5"	No sample recovery	
20				

TEST BORING - WELL CONSTRUCTION LOG

PROJECT	Old Dominion Electric Cooperative - Clover, Virginia		**BORING NO.** PW-5
CLIENT	H.B. Zachry Company and Black & Veatch	**JOB NO.** 931010	**SHEET 2 OF 2**

DEPTH FEET	SAMPLE NUMBER	BLOWS PER 6"	IDENTIFICATION	REMARKS
	S-5	50/1"	No sample recovery	Split spoon wet
25				
	S-6	50/4"	Red brown silty sand (SM) wet (Partially weathered rock)	
30				
			Auger refusal for 6 1/4" auger at 32.00'	
35				
40				Failing F-7 drilling rig reamed 8 inch hole to 41 feet to set well casing and screen. Used mud rotary drilling method.
45				

WELL CONSTRUCTION



TEST BORING - WELL CONSTRUCTION LOG

PROJECT Old Dominion Electric Cooperative - Clover, Virginia		BORING NO. PW-6
CLIENT H.B. Zachry Company and Black & Veatch		SHEET 1 OF 2
DRILLING CONTRACTOR Bore and Core		JOB NO. 931010
PURPOSE Down gradient Monitoring Well for Holding Pond		ELEV. MP GR

GROUND WATER					CASING	SAMPLE	CORE	WELL	DATUM
DATE	TIME	DEPTH	CASING	TYPE					STARTED 10/28/93
				DIAMETER					COMPLETED 11/10/93
				WEIGHT				DRILLER	Dubesky/Cassell
				FALL				GEOLOGIST	M.Armstrong (#710)

DEPTH FEET	SAMPLE NUMBER	BLOWS PER 6"	WELL CONSTRUCTION	IDENTIFICATION	REMARKS
			Concrete	Fill material	CME 75 rig drilled borehole using 6 1/4 inch O.D. 3 1/8 inch I.D. hollow stem augers
			6 7/8 inch protective steel casing		
	S-1	10 9 8	8 inch borehole	Yellow brown clayey silt to silty clay (ML to CL) dry	
5			4 inch PVC Sch 80 casing		
			Cement grout		
	S-2	41 50/5"		Black to gray silty sand (SM) dry (partially weathered rock)	
10					
	S-3	32 32 50/5"		Black, gray, tan, pink micaceous silty sand to sandy silt (SM to ML) dry (partially weathered rock)	
15					
	S-4	50/5"		Same as above	
			Bentonite		
20					

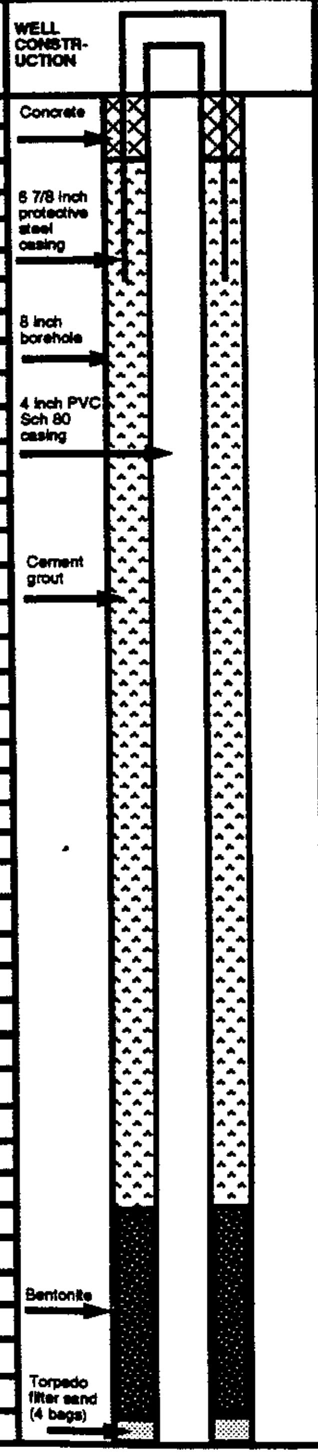
TEST BORING - WELL CONSTRUCTION LOG

PROJECT Old Dominion Electric Cooperative - Clover, Virginia	**BORING NO.** PW-7
CLIENT H.B. Zachry Company and Black & Veatch	**SHEET 1 OF** 2
DRILLING CONTRACTOR Bore and Core	**JOB NO.** 931010
PURPOSE Down gradient Monitoring Well for Coal Pile/ Limestone Runoff Pond	**ELEV.** MP GR

GROUND WATER					CASING	SAMPLE	CORE	WELL	DATUM
DATE	TIME	DEPTH	CASING	TYPE					STARTED 10/28/93
				DIAMETER					COMPLETED 10/28/93
				WEIGHT				DRILLER	Dubesky/Cassell
				FALL				GEOLOGIST	M.Armstrong (#710)

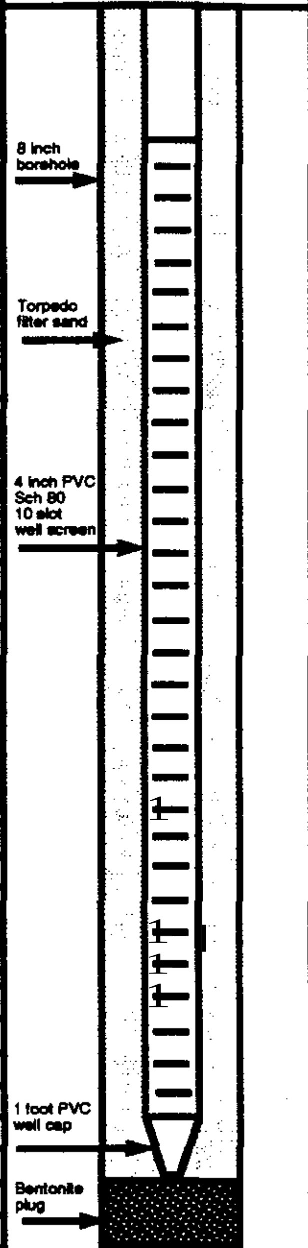
DEPTH FEET	SAMPLE NUMBER	BLOWS PER 6"	IDENTIFICATION	REMARKS
0				CME 75 rig drilled borehole using 6 1/4 inch O.D. 3 1/8 inch I.D. hollow stem augers
3–4.5	S-1	21 15 18	Yellow brown/tan clayey silt to silty clay (ML) dry	
5				
8–9.5	S-2	12 21 15	Black/tan/yellow silty clay to clayey silt (ML to CL) dry, (partially weathered rock)	
10				
13–14.5	S-3	12 19 26	Tan, green silty clay (CL) dry	
15				
18	S-4	50/5"	Tan/light brown, pink silty sand (SM) dry (partially weathered rock)	
20				

WELL CONSTRUCTION



TEST BORING - WELL CONSTRUCTION LOG

PROJECT	Old Dominion Electric Cooperative - Clover, Virginia	BORING NO.	PW-7
CLIENT	H.B. Zachry Company and Black & Veatch	JOB NO. 931010	SHEET 2 OF 2



DEPTH FEET	SAMPLE NUMBER	BLOWS PER 6"	IDENTIFICATION	REMARKS
	S-5	50/0"	No Sample Recovery	
25				
	S-6	50/1"	No Sample Recovery	Split spoon wet
30				
	S-7	50/4"	Tan/orange Silty Sand (SM) (partially weathered rock) very little recovery	
35				
	S-8	50/2"	Black silty sand (SM) (partially weathered rock) Terminated 6 1/4" borehole at 38.17'	Failing F-7 drilling rig reamed 8 inch hole to 40 feet to set well casing. Used mud rotary drilling method.
40				
45				

TEST BORING - WELL CONSTRUCTION LOG

PROJECT Old Dominion Electric Cooperative - Clover, Virginia		BORING NO. PW-8
CLIENT H.B. Zachry Company and Black & Veatch		SHEET 1 OF 2
DRILLING CONTRACTOR Bore and Core		JOB NO. 931010
PURPOSE Down gradient Monitoring Well for Coal Pile/ Limestone Runoff Pond		ELEV. MP / GR

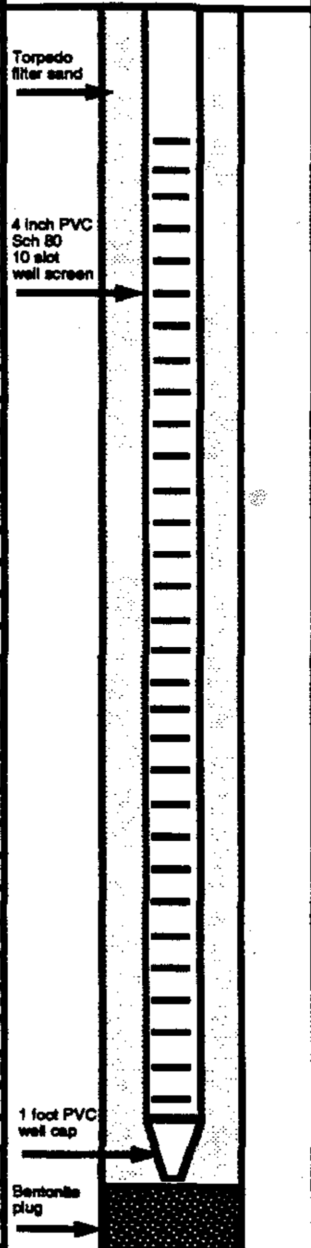
GROUND WATER					CASING	SAMPLE	CORE	WELL	DATUM
DATE	TIME	DEPTH	CASING	TYPE					STARTED 10/28/93
				DIAMETER					COMPLETED 11/10/93
				WEIGHT				DRILLER	Dubesky/Cassell
				FALL				GEOLOGIST	M.Armstrong (#710)

DEPTH FEET	SAMPLE NUMBER	BLOWS PER 6"	WELL CONSTRUCTION	IDENTIFICATION	REMARKS
			Concrete		CME 75 rig drilled borehole using 6 1/4 inch O.D. 3 1/8 inch I.D. hollow stem augers
			6 7/8 inch protective steel casing		
	S-1	2 4 5	8 inch borehole	Red brown silty clay (CL) dry	
5			4 inch PVC Sch 80 casing		
			Cement grout		
	S-2	12 18 21		Tan to red brown silty clay (CL) dry	
10					
	S-3	6 9 11		Light gray to red brown silty clay (CL) slightly moist	
15					
			Bentonite		
	S-4	5 7 12		Tan, light brown silty sand (SP) wet, fine to coarse with large gravel	
20					

TEST BORING - WELL CONSTRUCTION LOG

PROJECT	Old Dominion Electric Cooperative - Clover, Virginia			**BORING NO.**	PW-8
CLIENT	H.B. Zachry Company and Black & Veatch	**JOB NO.**	931010	**SHEET 2 OF 2**	

DEPTH FEET	SAMPLE NUMBER	BLOWS PER 6"	WELL CONSTRUCTION	IDENTIFICATION	REMARKS
					Hit Rock at 22 feet
	S-5	50/0"		No Sample Recovery	
				Terminated 6 1/4" borehole at 23.00'	
25					
30					
35					
					Failing F-7 drilling rig reamed 8 inch hole to 39 feet to set well casing. Used mud rotary drilling method.
40					
45					



SOIL BORING LOG

BORING NO. PW-12

Client: Dominion Resource Services		Drilling Start Date: 7-28-15	Drilling End Date: 7-28-15	Page 1 of 3
Site: Clover Power Station		Drilling Method: Hollow Stem Auger		Project Number: 232002.0.0
Geologist/Technician: Rick Mayer	Driller (name/company): Joshua Ellingworth arratt Wolff	Drill Rig Type: CME-75 Mobile		Borehole Diameter (in.): 8.25
Boring Coordinates: N: E:	Total Depth (ft.): 42.00	Measuring Point Elevation (ft.):		
Datum Description:	Datum Elevation (ft.):	Checked by: RAM		

Sample Interval	% Recovery	Sample Type	Blow Counts	PID (ppm)	Depth (feet)	Stratigraphy	LITHOLOGIC DESCRIPTION
					0		TOPSOIL, silty, black.
5-7	46	SS	5 8 12 13		5		LEAN CLAY (CL), 90% clay, 10% fine to medium-grained sand, mps = 2 mm, medium plasticity, red and yellowish- brown mottling, dry, very stiff, slightly foliated (Cohesive Fill).
10-12	100	SS	3 3 3 5		10		SILT (ML), 30% clay, 10% fine-grained sand, mps = 2 mm, low plasticity, reddish-brown and light gray, moist, medium stiff, slightly foliated (Residual Soil).
15-17	50	SS	2 3 2 3		15		SANDY SILT (ML), 40% fine to medium-grained sand, 10% clay, mps = 5 mm, nonplastic, yellowish-brown, moist, medium stiff, homogeneous (Residual Soil).

Continued Next Page

SOIL BORING LOG

BORING NO. PW-12

Client: Dominion Resource Services		Drilling Start Date: 7-28-15	Drilling End Date: 7-28-15	Page 2 of 3
Site: Clover Power Station		Drilling Method: Hollow Stem Auger		Project Number: 232002.0.0
Geologist/Technician: Rick Mayer	Driller (name/company): Joshua Ellingworth arratt Wolff	Drill Rig Type: CME-75 Mobile		Borehole Diameter (in.): 8.25
Boring Coordinates: N: E:	Total Depth (ft.): 42.00	Measuring Point Elevation (ft.):		
Datum Description:	Datum Elevation (ft.):	Checked by: RAM		

Sample Interval	% Recovery	Sample Type	Blow Counts	PID (ppm)	Depth (feet)	Stratigraphy	LITHOLOGIC DESCRIPTION
	54	SS	1 3 2 5		20–25		SILTY SAND (SM), 55% fine to coarse-grained sand, 45% silt, mps = 5 mm, nonplastic, yellowish-brown, micaceous, moist to wet at 21 feet, loose, homogeneous (Saprolite).
	83	SS	3 5 10 11		25–30		SILTY SAND (SM), 65% fine to coarse-grained sand, 35% silt, mps = 10 mm, nonplastic, yellowish-brown, wet, medium dense, 1 inch thick quartz vein at 26 feet, slight foliations (Saprolite).
	63	SS	15 23 19 35		30–35		SILTY SAND (SM), 75% fine to coarse-grained sand, 25% silt, mps = 5 mm, nonplastic, yellowish-brown and light pink, wet, very dense, foliated (Saprolite).
	54	SS	31 45 31 50/5		35–40		-as above; dry.

Greenville (ver. 9/1/97)

Continued Next Page

SOIL BORING LOG

BORING NO. PW-12

Client: Dominion Resource Services		Drilling Start Date: 7-28-15	Drilling End Date: 7-28-15	Page 3 of 3
Site: Clover Power Station		Drilling Method: Hollow Stem Auger		Project Number: 232002.0.0
Geologist/Technician: Rick Mayer	Driller (name/company): Joshua Ellingworth arratt Wolff	Drill Rig Type: CME-75 Mobile		Borehole Diameter (in.): 8.25
Boring Coordinates: N: E:	Total Depth (ft.): 42.00	Measuring Point Elevation (ft.):		
Datum Description:	Datum Elevation (ft.):	Checked by: RAM		

Sample Interval	% Recovery	Sample Type	Blow Counts	PID (ppm)	Depth (feet)	Stratigraphy	LITHOLOGIC DESCRIPTION
	46	SS	11 15 27 38		41		SILT (ML), 55% silt, 30% clay, 15% fine to medium-grained sand, nonplastic, yellowish-brown, moist, very stiff, slight foliation (Saprolite).
					42		SILTY SAND (SM), 75% fine to coarse-grained sand, 25% silt, nonplastic, yellowish-brown and light pink, dry, very dense, foliated (Saprolite).
					43		**BORING TERMINATED AT 42 FEET**
					44		
					45		
					46		
					47		
					48		
					49		
					50		
					51		
					52		
					53		
					54		
					55		
					56		
					57		
					58		
					59		

SOIL BORING LOG

BORING NO. PW-13

Client: Dominion Resource Services		Drilling Start Date: 7-28-15	Drilling End Date: 7-29-15	Page 1 of 3
Site: Clover Power Station		Drilling Method: Hollow Stem Auger		Project Number: 232002.0.0
Geologist/Technician: Rick Mayer	Driller (name/company): Joshua Ellingworth arratt Wolff	Drill Rig Type: CME-75 Mobile		Borehole Diameter (in.): 8.25
Boring Coordinates: N: E:	Total Depth (ft.): 50.20	Measuring Point Elevation (ft.):		
Datum Description:	Datum Elevation (ft.):	Checked by: RAM		

Sample Interval	% Recovery	Sample Type	Blow Counts	PID (ppm)	Depth (feet)	LITHOLOGIC DESCRIPTION
					0	TOPSOIL, silty, brown.
4-6	79	SS	2 3 1 3		4	LEAN CLAY (CL), 70% clay, 20% silt, 10% fine-grained sand, mps = 2 mm, meidum plasticity, reddish-brown, dry, soft, slightly micaceous, homogeneous (Cohesive Fill).
9-11	33	SS	4 7 8 10		9	as above; moist, very stiff.
14-16	33	SS	4 8 9 13		14	LEAN CLAY with SAND (CL), 60% clay, 20% silt, 20% fine to medium-grained sand, mps = 10 mm, medium plasticity, reddish-brown and yellowish-brown, moist, very stiff, homogeneous (Cohesive Fill).
19-	46	SS	3 4		19	FAT CLAY (CH), 90% clay, 10% fine-grained sand, mps = 2 mm, trace roots, high plasticity, yellowish-brown, moist, stiff, homogeneous (Residual Soil).

Continued Next Page

SOIL BORING LOG

BORING NO. PW-13

Client: Dominion Resource Services		Drilling Start Date: 7-28-15	Drilling End Date: 7-29-15	Page 2 of 3
Site: Clover Power Station		Drilling Method: Hollow Stem Auger		Project Number: 232002.0.0
Geologist/Technician: Rick Mayer	Driller (name/company): Joshua Ellingworth arratt Wolff	Drill Rig Type: CME-75 Mobile		Borehole Diameter (in.): 8.25
Boring Coordinates: N: E:	Total Depth (ft.): 50.20	Measuring Point Elevation (ft.):		
Datum Description:	Datum Elevation (ft.):	Checked by: RAM		

Sample Interval	% Recovery	Sample Type	Blow Counts	PID (ppm)	Depth (feet)	Stratigraphy	LITHOLOGIC DESCRIPTION
			6 6		21		FAT CLAY (CH), 90% clay, 10% fine-grained sand, mps = 2 mm, trace roots, high plasticity, yellowish-brown, moist, stiff, homogeneous (Residual Soil).
					22		
					23		
	42	SS	5 5 7 14		24 25		SANDY SILT (ML), 60% silt, 30% fine to medium-grained sand, 10% clay, mps = 5 mm, nonplastic, yellowish-brown, moist, very stiff, foliated (Saprolite).
					26 27 28		
	42	SS	14 17 20 22		29 30		SANDY SILT (ML), 50% silt, 40% fine to medium-grained sand, 10% clay, mps = 5 mm, nonplastic, greenish-gray, moist to wet at approximently 31 feet, micaceous, hard, strong foliation (Saprolite).
					31 32 33		
	65	SS	8 8 18 50/5		34		-as above.
					35 36 37 38		SILTY SAND (SM), 75% fine to coarse-grained sand, 25% silt, mps = 5 mm, nonplastic, reddish-yellow and yellowish-pink, dry, very dense, strong foliation (Saprolite).
	100	SS	50/6		39		-as above.

Continued Next Page

SOIL BORING LOG

BORING NO. PW-13

Client: Dominion Resource Services		Drilling Start Date: 7-28-15	Drilling End Date: 7-29-15	Page 3 of 3	
Site: Clover Power Station		Drilling Method: Hollow Stem Auger		Project Number: 232002.0.0	
Geologist/Technician: Rick Mayer	Driller (name/company): Joshua Ellingworth Parratt Wolff	Drill Rig Type: CME-75 Mobile		Borehole Diameter (in.): 8.25	
Boring Coordinates: N: E:	Total Depth (ft.): 50.20	Measuring Point Elevation (ft.):			
Datum Description:	Datum Elevation (ft.):	Checked by: RAM			

Sample Interval	% Recovery	Sample Type	Blow Counts	PID (ppm)	Depth (feet)	Stratigraphy	LITHOLOGIC DESCRIPTION
					40–50.2		SILTY SAND (SM), 75% fine to coarse-grained sand, 25% silt, mps = 5 mm, nonplastic, reddish-yellow and yellowish-pink, dry, very dense, strong foliation (Saprolite).
	0	SS	50/0		44		No recovery.
	100	SS	50/1		49		SILTY SAND (SM), 80% fine to medium-grained sand, 20% silt, mps = 5 mm, nonplastic, reddish-yellow, wet, very dense, foliated (Saprolite).
					50.2		**BORING TERMINATED AT 50.20 FEET DUE TO AUGER REFUSAL**

Appendix E
Well Inspection Report Form

Well Inspection Report

Inspector's Name: ______________________________ Date of Inspection: ______________

Inspector's Signature: ______________________________

INSPECTION ITEM	POTENTIAL DEFICIENCIES	OBSERVATIONS AND ACTIONS
	Inspector must check at minimum for specific deficiencies listed.	Note deficiencies found.
		Record actions to correct deficiencies.
		Record and initial date of completion.

Groundwater Monitoring Wells:

____

____

____

____

INSPECTION ITEM	POTENTIAL DEFICIENCIES	OBSERVATIONS/ACTIONS
Protective Casing	Damage, Deterioration	
Lock	Corrosion, Malfunction, Damage, and Tampering	
Concrete Pad	Cracking, Erosion	
Surrounding Area	Inaccessibility, excessive vegetative growth	
Well Label	Missing, illegible	
Other		

Appendix F
Field Data Information Sheet

WATER SAMPLE LOG

PROJECT NAME: 0	PREPARED		CHECKED	
PROJECT NUMBER: 0.00	BY 0	DATE:	BY:	DATE:

SAMPLE ID:

WELL DIAMETER: ☐ 2" ☐ 4" ☐ 6" ☐ OTHER ____________

WELL MATERIAL: ☐ PVC ☐ SS ☐ IRON ☐ GALVANIZED STEEL ☐ OTHER ____________

SAMPLE TYPE: ☐ GW ☐ WW ☐ SW ☐ DI ☐ LEACHATE ☐ OTHER ____________

PURGING	TIME:	DATE:	SAMPLE	TIME:	DATE:

PURGING

PURGE METHOD: ☐ PUMP ____________ ☐ BAILER ____________

DEPTH TO WATER: _________ T/ PVC

DEPTH TO BOTTOM: _________ T/ PVC

WELL VOLUME: _________ ☐ LITERS ☐ GALLONS

VOLUME REMOVED: _________ ☐ LITERS ☐ GALLONS

COLOR: ____________ ODOR: __________

TURBIDITY

☐ NONE ☐ SLIGHT ☐ MODERATE ☐ VERY

DISPOSAL METHOD: ☐ GROUND ☐ DRUM ☐ OTHER

SAMPLE

PH: _________ SU CONDUCTIVITY: ___________ umhos/cm

ORP: _________ mV DO: ________ mg/L

TURBIDITY: ________ NTU

☐ NONE ☐ SLIGHT ☐ MODERATE ☐ VERY

TEMPERATURE: _________ °C OTHER: ____________

COLOR: ____________ ODOR: ____________

FILTRATE (0.45 um) ☐ YES ☐ NO

FILTRATE COLOR: ____________ FILTRATE ODOR: ____________

QC SAMPLE: ☐ MS/MSD ☐ DUP- _________

COMMENTS:

TIME	PURGE RATE (ML/MIN)	PH (SU)	CONDUCTIVITY (umhos/cm)	ORP (mV)	D.O. (mg/L)	TURBIDITY (NTU)	TEMPERATURE (°C)	WATER LEVEL (FEET)	CUMULATIVE PURGE VOLUME (GAL OR L)
									INITIAL

NOTE: STABILIZATION TEST IS COMPLETE WHEN 3 SUCCESSIVE READINGS ARE WITHIN THE FOLLOWING LIMITS:

pH: +/- **10 %** COND.: +/- **10 %** ORP: +/- **10 %** D.O.: +/- **10 %** TURB: +/- **10 %** or </= **5** TEMP.: +/- **0.5°C**

BOTTLES FILLED — PRESERVATIVE CODES: A - NONE B - HNO3 C - H2SO4 D - NaOH E - HCL F - _______

NUMBER	SIZE	TYPE	PRESERVATIVE	FILTERED	NUMBER	SIZE	TYPE	PRESERVATIVE	FILTERED
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N

SHIPPING METHOD: ____________	DATE SHIPPED: ____________	AIRBILL NUMBER: ____________
COC NUMBER: ____________	SIGNATURE: ____________	DATE SIGNED: ____________

Appendix G
Example Sample Label, Sample Seal, and Chain-of-Custody Form

AIR WATER & SOIL LABORATORIES, INC.

1941 REYMET ROAD
RICHMOND, VIRGINIA 23237
(804) 358-8295 PHONE
(804)358-8297 FAX

Chain of Custody
Form #: D1331
Rev. 1.0
Effective: Feb 14, 2014

CHAIN OF CUSTODY

PAGE ______OF ______

COMPANY NAME:	INVOICE TO:	PROJECT NAME/Quote #:
CONTACT:	INVOICE CONTACT:	SITE NAME:
ADDRESS:	INVOICE ADDRESS:	PROJECT NUMBER:
PHONE #:	INVOICE PHONE #:	P.O. #:
FAX #:	EMAIL:	Pretreatment Program:
Is sample for compliance reporting? YES NO	Is sample from a chlorinated supply? YES NO	PWS I.D. #:
SAMPLER NAME (PRINT):	SAMPLER SIGNATURE:	**Turn Around Time: Day(s)**

Matrix Codes: WW=Waste Water/Storm Water GW=Ground Water DW=Drinking Water S=Soil/Solids OR=Organic A=Air WP=Wipe OT=Other______________

CLIENT SAMPLE I.D.	Grab	Composite	Field Filtered (Dissolved Metals)	Composite Start Date	Composite Start Time	Grab Date or Composite Stop Date	Grab Time or Composite Stop Time	Time Preserved	Matrix (See Codes)	Number of Containers	ANALYSIS / (PRESERVATIVE)								COMMENTS **Preservative Codes**: N=Nitric Acid C=Hydrochloric Acid S=Sulfuric Acid H=Sodium Hydroxide A=Ascorbic Acid Z=Zinc Acetate T=Sodium Thiosulfate M=Methanol PLEASE NOTE PRESERVATIVE(S), INTERFERENCE CHECKS or PUMP RATE (L/min)
1)																			
2)																			
3)																			
4)																			
5)																			
6)																			
7)																			
8)																			
9)																			
10)																			

RELINQUISHED:	DATE / TIME	RECEIVED:	DATE / TIME	**QC Data Package** Level I ☐	**LAB USE ONLY** **COOLER TEMP ________°C**
RELINQUISHED:	DATE / TIME	RECEIVED:	DATE / TIME	Level II ☐ Level III ☐	
RELINQUISHED:	DATE / TIME	RECEIVED:	DATE / TIME	Level IV ☐	

Sample Label

AIR WATER & SOIL LABORATORIES, INC.

SAMPLE ID	
SAMPLE DATE	SAMPLE TIME
SAMPLED BY	PRESERVATIVE
ANALYSIS REQUESTED	___ GRAB ___ COMPOSITE

Sample/Cooler Seal

CUSTODY SEAL

DATE ____________________

SIGNATURE ____________________

QEC
Quality Environmental Containers
800-255-3950 • 304-255-3900